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70-502

Microsoft® .NET Framework 3.5– Windows® Presentation Foundation

Matthew A. Stoecker

SELF-PACED

Training Kit

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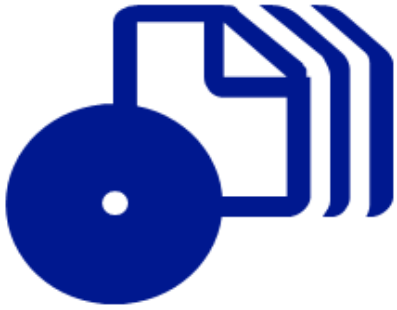

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Acknowledgments

Thank you to my friends and family. It isn't easy dealing with a person who is going crazy trying to write a book. Thanks for understanding when I had to work all night. Thanks for understanding when I needed to stay home and write on Friday night instead of going to see a movie. Thanks for putting up with me when all I talked about was how I needed to work on this book. This especially means thanks to you, Libby.

Introduction

This training kit is designed for developers who plan to take the Microsoft Certified IT Professional (MCITP) Exam 70-502, as well as for developers who need to know how to develop Microsoft Windows Presentation Foundation (WPF)–based applications using Microsoft .NET Framework 3.5. We assume that before using this training kit, you already have a working knowledge of Windows, Microsoft Visual Basic or C# (or both), and Extensible Application Markup Language (XAML).

By using this training kit, you will learn how to do the following:

- Create a WPF application
- Build user interfaces using WPF controls
- Add and manage content in a WPF application
- Bind WPF controls to data sources
- Customize the appearance of your WPF application
- Configure a WPF application
- Deploy a WPF application to its intended audience

Hardware Requirements

The following hardware is required to complete the practice exercises:

- A computer with a 1.6-gigahertz (GHz) or faster processor
- A minimum of 384 megabytes (MB) of random access memory (RAM)
- A minimum of 2.2 gigabytes (GB) of available hard disk space is required to install VS 2008. Additionally, 50 megabytes (MB) of available hard disk space is required to install the labs.
- A DVD-ROM drive
- A 1024 x 768 or higher resolution display with 256 colors or more
- A keyboard and Microsoft mouse or compatible pointing device

Software Requirements

The following software is required to complete the practice exercises:

- One of the following operating systems:
  - Windows Vista (any edition except Windows Vista Starter)
  - Windows XP with Service Pack 2 or later (any edition except Windows XP Starter)
  - Windows Server 2003 with Service Pack 1 or later (any edition)
  - Windows Server 2003 R2 or later (any edition)
  - Windows Server 2008
- Microsoft Visual Studio 2008

NOTE A 90-day evaluation edition of Visual Studio 2008 Professional Edition is included on a DVD that comes with this training kit.

Using the CD and DVD

A companion CD and an evaluation software DVD are included with this training kit. The companion CD contains the following:

- **Practice Tests** You can reinforce your understanding of how to create WPF applications in Visual Studio 2008 with .NET Framework 3.5 by using electronic practice tests that you can customize to meet your needs from the pool of Lesson Review questions in this book. Alternatively, you can practice for the 70-502 certification exam by using tests created from a pool of 200 realistic exam questions, which will give you enough different practice tests to ensure you're prepared.
- **Sample Files** Most chapters in this training kit include sample files that are associated with the lab exercises at the end of every lesson. For some exercises, you are instructed to open a project prior to starting the exercise. For other exercises, you create a project on your own and can reference a completed project on the CD if you have a problem following the exercise procedures. Sample files can be installed to your hard drive by simply copying them to the appropriate directory.

After copying the sample files from the CD to your hard drive you must clear the Read Only attribute in order to work with the files on your hard drive.

- **eBook** An electronic version (eBook) of this training kit is included for use at times when you don't want to carry the printed book with you. The eBook is in Portable Document Format (PDF) and you can view it by using Adobe Acrobat or Adobe Reader. You can use the eBook to cut and paste code as you work through the exercises.

The evaluation software DVD contains a 90-day evaluation edition of Visual Studio 2008 Professional Edition, in case you want to use it instead of a full version of Visual Studio 2008 to complete the exercises in this book.

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How to Install the Practice Tests

To install the practice test software from the companion CD to your hard disk, perform the following steps:

1. Insert the companion CD into your CD drive and accept the license agreement that appears onscreen. A CD menu appears.

NOTE If the CD menu or the license agreement doesn't appear, AutoRun might be disabled on your computer. Refer to the Readme.txt file on the CD-ROM for alternative installation instructions.

2. Click Practice Tests and follow the instructions on the screen.

How to Use the Practice Tests

To start the practice test software, follow these steps:

1. Click Start and select All Programs and Microsoft Press Training Kit Exam Prep. A window appears that shows all the Microsoft Press training kit exam prep suites that are installed on your computer.
2. Double-click the lesson review or practice test you want to use.

Lesson Review Options

When you start a lesson review, the Custom Mode dialog box appears, allowing you to configure your test. You can click OK to accept the defaults or you can customize the number of questions you want, the way the practice test software works, which exam objectives you want the questions to relate to, and whether you want your lesson review to be timed. If you are retaking a test, you can select whether you want to see all the questions again or only those questions you previously skipped or answered incorrectly.

After you click OK, your lesson review starts. You can take the test as follows:

- To take the test, answer the questions and use the Next, Previous, and Go To buttons to move from question to question.
- After you answer an individual question, if you want to see which answers are correct, along with an explanation of each correct answer, click Explanation.
- If you would rather wait until the end of the test to see how you did, answer all the questions and then click Score Test. You see a summary of the exam objectives that you chose and the percentage of questions you got right overall and per objective. You can print a copy of your test, review your answers, or retake the test.

Practice Test Options

When you start a practice test, you can choose whether to take the test in Certification Mode, Study Mode, or Custom Mode.

- **Certification Mode** Closely resembles the experience of taking a certification exam. The test has a set number of questions, it is timed, and you cannot pause and restart the timer.
- **Study Mode** Creates an untimed test in which you can review the correct answers and the explanations after you answer each question.
- **Custom Mode** Gives you full control over the test options so that you can customize them as you like.

In all modes, the user interface you see when taking the test is basically the same, but different options are enabled or disabled, depending on the mode. The main options are discussed in the previous section, "Lesson Review Options."

When you review your answer to an individual practice test question, a "References" section is provided. This section lists where in the training kit you can find the information

that relates to that question, and it also provides links to other sources of information. After you click Test Results to score your entire practice test, you can click the Learning Plan tab to see a list of references for every objective.

How to Uninstall the Practice Tests

To uninstall the practice test software for a training kit, use the Add Or Remove Programs option in the Control Panel in Windows.

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Chapter 2

Events, Commands, and Settings

Events and commands form the basis of the architecture for intra-application communication in Windows Presentation Foundation (WPF) applications. Routed events can be raised by multiple controls and allow a fine level of control over user input. Commands are a welcome addition to the Microsoft .NET Framework and provide a central architecture for enabling and disabling high-level tasks. Application settings allow you to persist values between application sessions. In this chapter, you will learn to configure these features.

Exam objectives in this chapter:

- Configure event handling.
- Configure commands.
- Configure application settings.

Lessons in this chapter:

- Lesson 1: Configuring Events and Event Handling 59
- Lesson 2: Configuring Commands 72
- Lesson 3: Configuring Application Settings 86

Before You Begin

To complete the lessons in this chapter, you must have

- A computer that meets or exceeds the minimum hardware requirements listed in the "About This Book" section at the beginning of the book
- Microsoft Visual Studio 2005 Professional Edition installed on your computer
- An understanding of Microsoft Visual Basic or C# syntax and familiarity with the .NET Framework

Real World

Matthew Stoecker

By using WPF routed events and commands, I find I have a much finer control over how my user interfaces respond compared to in a Windows Forms application. The Routed Event architecture allows me to implement complex event handling strategies, and the Command architecture provides a way to approach programming common tasks in my user interfaces.

Lesson 1: Configuring Events and Event Handling

Events in WPF programming are considerably different from those in traditional Windows Forms programming. WPF introduces routed events, which can be raised by multiple controls and handled by multiple handlers. *Routed events* allow you to add multiple levels of complexity and sophistication to your user interface and the way it responds to user input. In this lesson, you will learn about routed events, including how to handle a routed event, define and register a new routed event, handle an application lifetime event, and use the *EventManager* class.

After this lesson, you will be able to:

- Explain the difference between a direct event, a bubbling event, and a tunneling event
- Define and register a new routed event
- Define static class event handlers
- Handle an event in a WPF application
- Handle an attached event in a WPF application
- Handle application lifetime events
- Use the *EventManager* class

Estimated lesson time: 30 minutes

Events have been a familiar part of Microsoft Windows programming for years. An *event* is a message sent by an object, such as a control or other part of the user interface, that the program responds to (or handles) by executing code. While the traditional .NET event architecture is still present in WPF programming, WPF builds upon the event concept by introducing routed events.

A key concept to remember in event routing is the control containment hierarchy. In WPF user interfaces, controls frequently contain other controls. For example, a typical user interface might consist of a top-level *Window* object, which contains a *Grid* object, which itself might contain several controls, one of which could be a *ToolBar* control, which in turn contains several *Button* controls. The routed event architecture allows for an event that originates in one control to be raised by another control in the containment hierarchy. Thus, if the user clicks one of the *Button* controls on the toolbar, that event can be raised by the *Button,* the *ToolBar,* the *Grid,* or the *Window.*

Why is it useful to route events? Suppose, for example, that you are designing a user interface for a calculator program. As part of this application, you might have several

Button controls enclosed within a *Grid* control. Suppose that you wanted all button clicks in this grid to be handled by a single event handler? WPF raises the click event from the *Button,* the *Grid,* and any other control in the control containment hierarchy. As the developer, you can decide where and how the event is handled. Thus, you can provide a single event handler for all *Button Click* events originating from *Button* controls in the grid, simplifying code-writing tasks and ensuring consistency in event handling.

Types of Routed Events There are three different types of routed events: direct, bubbling, and tunneling.

Direct Events

Direct events are most similar to standard .NET events. Like a standard .NET event, a direct event is raised only by the control in which it originates. Because other controls in the control containment hierarchy do not raise these events, there is no opportunity for any other control to provide handlers for these events. An example of a direct event is the *MouseLeave* event.

Bubbling Events

Bubbling events are events that are raised first in the control where they originate and then are raised by each control in that control's control containment hierarchy, also known as a visual tree. The *MouseDown* event is an example of a bubbling event. Suppose that you have a *Label* contained inside a *FlowPanel* contained inside a *Window.* When the mouse button is pressed over the *Label,* the first control to raise the *MouseDown* event would be the *Label.* Then the *FlowPanel* would raise the *MouseDown* event, and then finally the *Window* itself. You could provide an event handler at any or all stages of the event process.

Tunneling Events

Tunneling events are the opposite of bubbling events. A *tunneling event* is raised first by the topmost container in the visual tree and then down through each successive container until it is finally raised by the element in which it originated. An example of a tunneling event is the *PreviewMouseDown* event. In the previous example, although the event originates with the *Label* control, the first control to raise the *PreviewMouseDown* event is the *Window,* then the *FlowPanel,* and then finally the *Label.* Tunneling events allow you the opportunity to intercept and handle events in the window or container before the event is raised by the specific control. This allows you to filter input, such as keystrokes, at varying levels.

In the .NET Framework, all tunneling events begin with the word "Preview," such as *PreviewKeyDown*, *PreviewMouseDown*, etc., and are typically defined in pairs with a complementary bubbling event. For example, the tunneling event *PreviewKeyDown* is paired with the bubbling event *KeyDown*. The tunneling event always is raised before its corresponding bubbling event, thus allowing an opportunity for higher-level controls in the visual tree to handle the event. Each tunneling event shares its instance of event arguments with its paired bubbling event. This fact is important to remember when handling events, and it will be discussed in greater detail later in this chapter.

RoutedEventArgs

All routed events include an instance of *RoutedEventArgs* (or a class that inherits *RoutedEventArgs*) in their signatures. The *RoutedEventArgs* class contains a wealth of information about the event and its source control. Table 2-1 describes the properties of the *RoutedEventArgs* class.

Table 2-1 *RoutedEventArgs* Properties

Property	Description
Handled	Indicates whether or not this event has been handled. By setting this property to *True*, you can halt further event bubbling or tunneling.
OriginalSource	Gets the object that originally raised the event. For most WPF controls, this will be the same as the object returned by the *Source* property. However, for some controls, such as composite controls, this property will return a different object.
RoutedEvent	Returns the *RoutedEvent* object for the event that was raised. When handling more than one event with the same event handler, you might need to refer to this property to distinguish which event has been raised.
Source	Returns the object that raised the event.

All *EventArgs* for routed events inherit the *RoutedEventArgs* class, but many of them provide additional information. For example, *KeyboardEventArgs* is used in keyboard events and provides information about keystrokes. Likewise, *MouseEventArgs*, used in mouse events, provides information about the state of the mouse when the event took place.

Quick Check

- What are the three kinds of routed events in WPF and how do they differ?

Quick Check Answer

- Routed events in WPF come in three different types: direct, tunneling, and bubbling. A direct event can be raised only by the element in which it originated. A bubbling event is raised first by the element in which it originates and then is raised by each successive container in the visual tree. A tunneling event is raised first by the topmost container in the visual tree and then down through each successive container until it is finally raised by the element in which it originated. Tunneling and bubbling events allow elements of the user interface to respond to events raised by their contained elements.

Attaching an Event Handler

The preferred way to attach an event handler is directly in the Extensible Application Markup Language (XAML) code. You set the event to the name of a method with the appropriate signature for that event. The following example demonstrates setting the event handler for a *Button* control's *Click* event, as shown in bold:

```
<Button Height="23" Margin="132,80,70,0" Name="button1"
   VerticalAlignment="Top" Click="button1_Click">Button</Button>
```

Just like setting a property, you must supply a string value that indicates the name of the method.

Attached Events

It is possible for a control to define a handler for an event that the control cannot itself raise. These incidents are called *attached events*. For example, consider *Button* controls in a *Grid*. The *Button* class defines a *Click* event, but the *Grid* class does not. However,

you still can define a handler for buttons in the grid by attaching the *Click* event of the *Button* control in the XAML code. The following example demonstrates attaching an event handler for a *Button* contained in a *Grid:*

```
<Grid Button.Click="button_Click">
   <Button Height="23" Margin="132,80,70,0" Name="button1"
   VerticalAlignment="Top" >Button</Button>
</Grid>
```

Now every time a button contained in the *Grid* shown here is clicked, the *button_Click* event handler will handle that event.

Handling a Tunneling or Bubbling Event

At times, you might want to halt the further handling of tunneling or bubbling events. For example, you might want to suppress keystroke handling at a particular level in the control hierarchy. You can handle an event and halt any further tunneling or bubbling by setting the *Handled* property of the *RoutedEventArgs* instance to *True*, as shown here:

```
' VB
Private Sub TextBox1_KeyDown(ByVal sender As System.Object, _
   ByVal e As System.Windows.Input.KeyEventArgs)
   e.Handled = True
End Sub

// C#
private void textBox1_KeyDown(object sender, KeyEventArgs e)
{
   e.Handled = true;
}
```

Note that tunneling events and their paired bubbling events (such as *PreviewKeyDown* and *KeyDown*) share the same instance of *RoutedEventArgs*. Thus, if you set the *Handled* property to *True* on a tunneling event, its corresponding bubbling event also is considered handled and is suppressed.

The *EventManager* Class

EventManager is a static class that manages the registration of all WPF routed events. Table 2-2 describes the methods of the *EventManager* class.

Table 2-2 *EventManager* Methods

Method	Description
GetRoutedEvents	Returns an array that contains all the routed events that have been registered in this application.
GetRoutedEventsForOwner	Returns an array of all the routed events that have been registered for a specified element in this application.
RegisterClassHandler	Registers a class-level event handler, as discussed in the section "Creating a Class-Level Event Handler," later in this chapter.
RegisterRoutedEvent	Registers an instance-level event handler, as discussed in the next section.

Defining a New Routed Event

You can use the *EventManager* class to define a new routed event for your WPF controls. The following procedure describes how to define a new routed event.

▶ **To define a new routed event**

1. Create a static, read-only definition for the event, as shown in this example:

```
' VB
Public Shared ReadOnly SuperClickEvent As RoutedEvent

// C#
public static readonly RoutedEvent SuperClickEvent;
```

2. Create a wrapper for the routed event that exposes it as a traditional .NET Framework event, as shown in this example:

```
' VB
Public Custom Event SuperClick As RoutedEventHandler
   AddHandler(ByVal value As RoutedEventHandler)
      Me.AddHandler(SuperClickEvent, value)
   End AddHandler

   RemoveHandler(ByVal value As RoutedEventHandler)
      Me.RemoveHandler(SuperClickEvent, value)
   End RemoveHandler
```

```
    RaiseEvent(ByVal sender As Object, _
       ByVal e As System.Windows.RoutedEventArgs)
       Me.RaiseEvent(e)
    End RaiseEvent
End Event

// C#
public event RoutedEventHandler SuperClick
{
    add
    {
       this.AddHandler(SuperClickEvent, value);
    }
    remove
    {
       this.RemoveHandler(SuperClickEvent, value);
    }
}
```

Note that you need to use a different *EventArgs* class than *RoutedEventArgs*. You need to derive a new class from *RoutedEventArgs* and create a new delegate that uses those event arguments.

3. Use *EventManager* to register the new event in the constructor of the class that owns this event. You must provide the name of the event, the routing strategy (direct, tunneling, or bubbling), the type of delegate that handles the event, and the type of the class that owns it. An example is shown here:

```
' VB
EventManager.RegisterRoutedEvent("SuperClick", _
   RoutingStrategy.Bubble, GetType(RoutedEventArgs), GetType(Window1))

// C#
EventManager.RegisterRoutedEvent("SuperClick",
   RoutingStrategy.Bubble, typeof(RoutedEventHandler), typeof(Window1));
```

Raising an Event

Once an event is defined, you can raise it in code by creating a new instance of *RoutedEventArgs* and using the *RaiseEvent* method, as shown here:

```
' VB
Dim myEventArgs As New RoutedEventArgs(myControl.myNewEvent)
MyBase.RaiseEvent(myEventArgs)

// C#
RoutedEventArgs myEventArgs = new RoutedEventArgs(myControl.myNewEvent);
RaiseEvent(myEventArgs);
```

Creating a Class-Level Event Handler

You can use the *EventManager* class to register a class-level event handler. A class-level event handler handles a particular event for all instances of a class, and is always invoked before instance handlers. Thus, you can screen and suppress events before they reach instance handlers. The following procedure describes how to implement a class-level event handler.

▶ To create a class-level event handler

1. Create a static method to handle the event. This method must have the same signature as the event. An example is shown here:

```
' VB
Private Shared Sub SuperClickHandlerMethod(ByVal sender As Object, _
   ByVal e As RoutedEventArgs)
   ' Handle the event here
End Sub

// C#
private static void SuperClickHandlerMethod(object sender, RoutedEventArgs e)
{
   // Handle the event here
}
```

2. In the static constructor for the class for which you are creating the class-level event handler, create a delegate to this method, as shown here:

```
' VB
Dim SuperClickHandler As New RoutedEventHandler( _
    AddressOf SuperClickHandlerMethod)

// C#
RoutedEventHandler SuperClickHandler = new
   RoutedEventHandler(SuperClickHandlerMethod);
```

3. Also in the static constructor, call *EventManager.RegisterClassHandler* to register the class-level event handler, as shown here:

```
' VB
EventManager.RegisterClassHandler(GetType(Window1), _
   SuperClickEvent, SuperClickHandler)

// C#
EventManager.RegisterClassHandler(typeof(Window1),
   SuperClickEvent,SuperClickHandler);
```

Application-Level Events

Every WPF application is wrapped by an *Application* object. The *Application* object provides a set of events that relate to the application's lifetime. You can handle these events

to execute code in response to application startup or closure. The *Application* object also provides a set of events related to navigation in page-based applications. These events were discussed in Chapter 1, "WPF Application Fundamentals." Table 2-3 describes the available application-level events, excluding the navigation events.

Table 2-3 Selected Application-Level Events

Event	Description
Activated	Occurs when you switch from another application to your program. It also is raised the first time you show a window.
Deactivated	Occurs when you switch to another program.
DispatcherUnhandledException	Raised when an unhandled exception occurs in your application. You can handle an unhandled exception in the event handler for this event by setting the *DispatcherUnhandledException-EventArgs.Handled* property to *True*.
Exit	Occurs when the application is shut down for any reason.
SessionEnding	Occurs when the Windows session is ending, such as when the user shuts down the computer or logs off.
Startup	Occurs as the application is started.

Application events are standard .NET events (rather than routed events), and you can create handlers for these events in the standard .NET way. The following procedure explains how to create an event handler for an application-level event.

▶ To create an application-level event handler

1. In Visual Studio, in the Solution Explorer, right-click Application.xaml (in Visual Basic) or App.xaml (in C#) and choose View Code to open the code file for the *Application* object.
2. Create a method to handle the event, as shown here:

```
' VB
Private Sub App_Startup(ByVal sender As Object, _
   ByVal e As StartupEventArgs)
   ' Handle event here
End Sub
```

```
// C#
void App_Startup(object sender, StartupEventArgs e)
{
   // Handle the event here
}
```

3. In XAML view for the *Application* object, add the event handler to the Application declaration, as shown in bold here:

```
<Application x:Class="Application"
   xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
   xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
   StartupUri="Window1.xaml" Startup="App_Startup">
```

Lab: Practice with Routed Events

In this lab, you practice using routed events. You create event handlers for the *TextBox.TextChanged* event in three different controls in the visual tree and observe how the event is raised and handled by each one.

Exercise: Creating an Event Handler

1. In Visual Studio, create a new WPF application.
2. From the Toolbox, drag a *TextBox* and three *RadioButton* controls onto the design surface. Note that at this point, these controls are contained by a *Grid* control that is in itself contained in the top-level *Window* control. Thus any bubbling events raised by the *TextBox* will bubble up first to the *Grid* and then to the *Window*.
3. In XAML view, set the display contents of the *RadioButton* controls as follows:

RadioButton	Content
RadioButton1	Handle Textbox.TextChanged in TextBox
RadioButton2	Handle Textbox.TextChanged in Grid
RadioButton3	Handle Textbox.TextChanged in Window

4. In the XAML for the *TextBox*, just before the />, type **TextChanged** and then press the Tab key twice. An entry for an event handler is created and a corresponding method is created in the code. The event-handler entry should look like the following:

```
TextChanged="TextBox1_TextChanged"
```

5. In the XAML for the *Grid*, type **TextBoxBase.TextChanged** and then press the Tab key twice to generate an event handler. The added XAML should look like this:

```
TextBoxBase.TextChanged="Grid_TextChanged"
```

6. In the XAML for the *Window*, type **TextBoxBase.TextChanged** and then press the Tab key twice to generate an event handler. The added XAML should look like this:

```
TextBoxBase.TextChanged="Window_TextChanged"
```

7. In Code view, add the following code to the *Textbox1_TextChanged* method:

```
' VB
MessageBox.Show("Event raised by Textbox")
e.Handled = RadioButton1.IsChecked

// C#
MessageBox.Show("Event raised by Textbox");
e.Handled = (bool)radioButton1.IsChecked;
```

8. Add the following code to the *Grid_TextChanged* method:

```
' VB
MessageBox.Show("Event raised by Grid")
e.Handled = RadioButton2.IsChecked

// C#
MessageBox.Show("Event raised by Grid");
e.Handled = (bool)radioButton2.IsChecked;
```

9. Add the following code to the *Window_TextChanged* method:

```
' VB
MessageBox.Show("Event raised by Window")
e.Handled = RadioButton3.IsChecked

// C#
MessageBox.Show("Event raised by Window");
e.Handled = (bool)radioButton3.IsChecked;
```

10. Press F5 to build and run your application. Type a letter in the *TextBox*. Three message boxes are displayed, each one indicating the control that raised the event. You can handle the event by choosing one of the radio buttons to halt event bubbling in the event handlers.

Lesson Summary

- WPF applications introduce a new kind of event called routed events. Routed events are raised by WPF controls.
- There are three kinds of routed events: direct, bubbling, and tunneling. Direct events are raised only by the control in which they originate. Bubbling and

tunneling events are raised by the control in which they originate and all controls that are higher in the visual tree.

- A tunneling event is raised first by the top-level control in the visual tree and tunnels down through the tree until it is finally raised by the control in which it originates. A bubbling event is raised first by the control in which the event originates and then bubbles up through the visual tree until it is finally raised by the top-level control in the visual tree.
- You can attach events that exist in contained controls to controls that are higher in the visual tree.
- The *EventManager* class exposes methods that allow you to manage events in your application. You can register a new routed event by using the *EventManager.RegisterRoutedEvent* class. You can create a class-level event handler by using *EventManager.RegisterClassHandler*.
- The *Application* object raises several events that can be handled to execute code at various points in the application's lifetime. You can handle application-level events in the code for the *Application* object.

Lesson Review

You can use the following questions to test your knowledge of the information in Lesson 1, "Configuring Events and Event Handling." The questions are also available on the companion CD of this book if you prefer to review them in electronic form.

NOTE Answers

Answers to these questions and explanations of why each answer choice is correct or incorrect are located in the "Answers" section at the end of the book.

---

1. Suppose you have the following XAML code:

```
<Window x:Class="WpfApplication1.Window1"
   xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
   xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
   Title="Window1" Height="300" Width="300"
   ButtonBase.Click="Window_Click">
   <Grid ButtonBase.Click="Grid_Click">
      <StackPanel Margin="47,54,31,108" Name="stackPanel1"
         ButtonBase.Click="stackPanel1_Click">
         <Button Height="23" Name="button1" Width="75">Button</Button>
      </StackPanel>
   </Grid>
</Window>
```

Which method will be executed first when *button1* is clicked?

A. *Button1_Click*

B. *stackPanel1_Click*

C. *Grid_Click*

D. *Window_Click*

2. Suppose you have the following XAML code:

```
<Window x:Class="WpfApplication1.Window1"
   xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
   xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
   Title="Window1" Height="300" Width="300" MouseDown="Window_MouseDown">
   <Grid PreviewMouseDown="Grid_PreviewMouseDown">
      <StackPanel Margin="47,54,31,108" Name="stackPanel1"
         PreviewMouseDown="stackPanel1_PreviewMouseDown">
         <Button Click="button1_Click" Height="23" Name="button1"
            Width="75">Button</Button>
      </StackPanel>
   </Grid>
</Window>
```

Which method will be executed first when *button1* is clicked?

A. *Window_MouseDown*

B. *Grid_PreviewMouseDown*

C. *stackPanel1_PreviewMouseDown*

D. *button1_Click*

3. You are writing an application that consists of a single WPF window. You have code that you want to execute when the window first appears and every time the window is activated. What application event or events should you handle to accomplish this goal?

A. *Activated*

B. *Startup*

C. *Activated* and *Startup*

D. *Deactivated* and *Startup*

Lesson 2: Configuring Commands

WPF introduces new objects called *commands*. Commands represent high-level tasks that are performed in the application. For example, *Paste* is an example of a command—it represents the task of copying an object from the clipboard into a container. WPF provides a cohesive architecture for creating commands, associating them with application tasks, and hooking those commands up to user interface (UI) elements. In this lesson, you will learn to use the built-in command library, associate these commands with UI elements, define command handlers, add a gesture to a command, and define custom commands.

After this lesson, you will be able to:

- Explain the different parts of a command
- Associate a command with a UI element
- Add a gesture to a command
- Execute a command
- Associate a command with a command handler
- Disable a command
- Create a custom command

Estimated lesson time: 30 minutes

Commands, such as Cut, Copy, and Paste, represent tasks. In past versions of the .NET Framework, there was no complete architecture for associating code with tasks. For example, suppose you wanted to implement a *Paste* task in your application. You would create the code to execute the task, and then associate your UI element with that code via events. For example, you might have a *MenuItem* element that triggers the code when selected. You also might have context menu items and perhaps even a *Button* control. In past versions of the .NET Framework, you would have had to create event handlers for each control with which you want to associate the task. In addition, you would have had to implement code to inactivate each of these controls if the task was unavailable. While not an impossible task, doing this requires tedious coding that can be fraught with errors.

Commands allow you to use a centralized architecture for tasks. You can associate any number of UI controls or input gestures to a command and bind that command to a handler that is executed when controls are activated or gestures are performed. Commands also keep track of whether or not they are available. If a command is disabled, UI elements associated with that command are disabled, too.

Command architecture consists of four principal parts. There is the *Command* object itself, which represents the task. Then there are command sources. A *command source* is a control or gesture that triggers the command when invoked. The *command handler* is a method that is executed when the command is invoked, and *CommandBinding* is an object that is used by the .NET Framework to track what commands are associated with which sources and handlers.

The .NET Framework provides several predefined commands that are available for use by developers. These built-in commands are static objects that are properties of five static classes, which are the following:

- *ApplicationCommands*
- *ComponentCommands*
- *EditingCommands*
- *MediaCommands*
- *NavigationCommands*

Each of these classes exposes a variety of static command objects that you can use in your applications. While some of these commands have default input bindings (for example, the *ApplicationCommands.Open* command has a default binding to the key combination Ctrl+O), none of these commands has any inherent functionality—you must create bindings and handlers for these commands to use them in your application.

A High-Level Procedure for Implementing a Command

The following section describes a high-level procedure for implementing command functionality. The steps of this procedure are discussed in greater detail in the subsequent sections.

▶ **To implement a command**

1. Decide on the command to use, whether it is one of the static commands exposed by the .NET Framework or a custom command.
2. Associate the command with any controls in the user interface and add any desired input gestures to the command.
3. Create a method to handle the command.
4. Create a *CommandBinding* that binds the *Command* object to the command handler and optionally to a method that handles *Command.CanExecute*.

5. Add the command binding to the *Commands* collection of the control or *Window* where the command is invoked.

Invoking Commands

Once a command has been implemented, you can invoke it by associating it with a control, using a gesture, or invoking it directly from code.

Associating Commands with Controls

Many WPF controls implement the *ICommandSource* interface, which allows them to have a command associated with them that is fired automatically when that control is invoked. For example, *Button* and *MenuItem* controls implement *ICommandSource* and thus expose a *Command* property. When this property is set to a command, that command is executed automatically when the control is clicked. You can set a command for a control in XAML, as shown here:

```
<Button Command="ApplicationCommands.Find" Height="23"
HorizontalAlignment="Right" Margin="0,0,38,80" Name="Button3"
VerticalAlignment="Bottom" Width="75">Button</Button>
```

Invoking Commands with Gestures

You also can register mouse and keyboard gestures with *Command* objects that invoke the command when those gestures occur. The following example code shows how to add a mouse gesture and a keyboard gesture to the *InputGestures* collection of the *Application.Find* command:

```
' VB
ApplicationCommands.Find.InputGestures.Add(New _
   MouseGesture(MouseAction.LeftClick, ModifierKeys.Control))
ApplicationCommands.Find.InputGestures.Add(New _
   KeyGesture(Key.Q, ModifierKeys.Control))

// C#
ApplicationCommands.Find.InputGestures.Add(new
   MouseGesture(MouseAction.LeftClick, ModifierKeys.Control));
ApplicationCommands.Find.InputGestures.Add(new
   KeyGesture(Key.Q, ModifierKeys.Control));
```

Once the code in the previous example is executed, the *Find* command executes either when the Ctrl key is held down and the left mouse button is clicked, or when the Ctrl key and the Q key are held down together (Ctrl+Q).

Invoking Commands from Code

You might want to invoke a command directly from code, such as in response to an event in a control that does not expose a *Command* property. To invoke a command directly, simply call the *Command.Execute* method, as shown here:

```
' VB
ApplicationCommands.Find.Execute(aParameter, TargetControl)

// C#
ApplicationCommands.Find.Execute(aParameter, TargetControl);
```

In this example, *aParameter* represents an object that contains any required parameter data for the command. If no parameter is needed, you can use *null* (*Nothing* in Visual Basic). *TargetControl* is a control where the command originates. The run time will start looking for *CommandBindings* in this control and then bubble up through the visual tree until an appropriate *CommandBinding* is found.

Command Handlers and Command Bindings

As stated before, just invoking a command doesn't actually do anything. Commands represent tasks, but they do not contain any of the code for the tasks they represent. To execute code when a command is invoked, you must create a *CommandBinding* that binds the command to a command handler.

Command Handlers

Any method with the correct signature can be a command handler. Command handlers have the following signature:

```
' VB
Private Sub myCommandHandler(ByVal sender As Object, _
   ByVal e As ExecutedRoutedEventArgs)
   ' Handle the command here
End Sub

// C#
private void myCommandHandler(object sender, ExecutedRoutedEventArgs e)
{
   // Handle the command here
}
```

ExecutedRoutedEventArgs is derived from *RoutedEventArgs* and thus exposes all the members that *RoutedEventArgs* does. In addition, it exposes a *Command* property that returns the *Command* object that is being handled.

Command Bindings

The *CommandBinding* object provides the glue that holds the whole command architecture together. A *CommandBinding* associates a command with a command handler. Adding a *CommandBinding* to the *CommandBindings* collection of the *Window* or a control registers the *CommandBinding* and allows the command handler to be called when the command is invoked. The following code demonstrates how to create and register a *CommandBinding:*

```
' VB
Dim abinding As New CommandBinding()
abinding.Command = ApplicationCommands.Find
AddHandler abinding.Executed, AddressOf myCommandHandler
Me.CommandBindings.Add(abinding)

// C#
CommandBinding abinding = new CommandBinding();
abinding.Command = ApplicationCommands.Find;
abinding.Executed += new ExecutedRoutedEventHandler(myCommandHandler);
this.CommandBindings.Add(abinding);
```

In the preceding example, you first create a new *CommandBinding* object. You then associate that *CommandBinding* object with a *Command* object. Next, you specify the command handler that will be executed when the command is invoked, and finally, you add the *CommandBinding* object to the *CommandBindings* collection of the *Window.* Thus, if an object in the window invokes the command, the corresponding command handler will be executed.

You also can define *CommandBindings* directly in the XAML. You can create a new binding and declaratively set the command it is associated with and the associated handlers. The following example demonstrates a new *CommandBinding* in the *CommandBinding* collection of the window that associates the *Application.Find* command with a handler:

```
<Window.CommandBindings>
   <CommandBinding Command="ApplicationCommands.Find"
      Executed="myCommandHandler" />
</Window.CommandBindings>
```

Command Bubbling

Note that all controls have their own *CommandBindings* collection in addition to the window's *CommandBindings* collection. This is because commands, like routed events, bubble up through the visual tree when they are invoked. Commands look for a binding first in the *CommandBindings* collection of the control in which they originate, and

then in the *CommandBindings* collections of controls higher on the visual tree. Like a *routedEvent,* you can stop further processing of the command by setting the *Handled* property of the *ExecutedRoutedEventArgs* parameter to *True*, as shown here:

```
' VB
Private Sub myCommandHandler(ByVal sender As Object, _
   ByVal e As ExecutedRoutedEventArgs)
   ' Stops further Command bubbling
   e.Handled = True
End Sub

// C#
private void myCommandHandler(object sender, ExecutedRoutedEventArgs e)
{
   // Handle the command here
   e.Handled = true;
}
```

Exam Tip Bubbling and tunneling are concepts that are new to WPF and that play important roles both in commands and how WPF handles routed events. Be certain that you understand the concepts of bubbling and tunneling events and bubbling commands for the exam. Remember that a command or event doesn't need to be handled by the same element in which it originates.

Disabling Commands

Any command that is not associated with a *CommandBinding* is automatically disabled. No action is taken when that command is invoked, and any control that has its *Command* property set to that command appears as disabled. However, there might be times that you want to disable a command that is in place and associated with controls and *CommandBindings.* For example, you might want the Print command to be disabled until the focus is on a document. The command architecture allows you to designate a method to handle the *Command.CanExecute* event. The *CanExecute* event is raised at various points in the course of application execution to determine whether a command is in a state that will allow execution.

Methods that handle the *CanExecute* event include an instance of *CanExecuteRoutedEventArgs* as a parameter. This class exposes a property called *CanExecute* that is a boolean value. If *CanExecute* is true, the command can be invoked. If it is false, the command is disabled. You can create a method that handles the *CanExecute* event, determines whether or not the application is in an appropriate state to allow command execution, and sets *e.CanExecute* to the appropriate value.

▶ To handle the *CanExecute* event

1. Create a method to handle the *CanExecute* event. This method should query the application to determine whether the application's state is appropriate to allow the command to be enabled. An example is shown here:

```
' VB
Private canExecute As Boolean
Private Sub abinding_CanExecute(ByVal sender As Object, _
   ByVal e As CanExecuteRoutedEventArgs)
   e.CanExecute = canExecute
End Sub

// C#
bool canExecute;
void abinding_CanExecute(object sender, CanExecuteRoutedEventArgs e)
{
   e.CanExecute = canExecute;
}
```

   In this example, the method returns the value represented by a private variable called *canExecute*. Presumably, the application sets this to False whenever it requires the command to be disabled.

2. Set the *CanExecute* handler on the *CommandBinding* to point to this method, as shown here:

```
' VB
' Assumes that you have already created a CommandBinding called abinding
AddHandler abinding.CanExecute, AddressOf abinding_CanExecute

// C#
// Assumes that you have already created a CommandBinding called abinding
abinding.CanExecute += new CanExecuteRoutedEventHandler(abinding_CanExecute);
```

   Alternatively, create a new binding in XAML and specify the handler there, as shown here in bold:

```
<Window.CommandBindings>
   <CommandBinding Command="ApplicationCommands.Find"
      Executed="CommandBinding_Executed"
      CanExecute="abinding_CanExecute" />
</Window.CommandBindings>
```

Creating Custom Commands

Although a wide variety of pre-existing commands is at your disposal, you might want to create your own custom commands. The best practice for custom commands is to follow the example set in the .NET Framework and create static classes (in C#) or

modules (in Visual Basic) that expose static instances of the custom command. This keeps multiple instances of the command from being created. You also can provide any custom configuration for the command in the static constructor of the class—for example, if you want to map any input gestures to the command. The following example shows how to create a static class that exposes a custom command called *Launch:*

```
' VB
Public Module MyCommands
   Private launch_command As RoutedUICommand
   Sub New()
      Dim myInputGestures As New InputGestureCollection
      myInputGestures.Add(New KeyGesture(Key.L, ModifierKeys.Control))
      launch_command = New RoutedUICommand("Launch", "Launch", _
        GetType(MyCommands), myInputGestures)
   End Sub
   Public ReadOnly Property Launch() As RoutedUICommand
      Get
         Return launch_command
      End Get
   End Property
End Module

// C#
public class MyCommands
{
   private static RoutedUICommand launch_command;
   static MyCommands()
   {
      InputGestureCollection myInputGestures = new
         InputGestureCollection();
      myInputGestures.Add(new KeyGesture(Key.L, ModifierKeys.Control));
      launch_command = new RoutedUICommand("Launch", "Launch",
         typeof(MyCommands), myInputGestures);
   }
   public RoutedUICommand Launch
   {
      get
      {
         return launch_command;
      }
   }
}
```

In this example, a static class or module is created to contain the custom command, which is exposed through a read-only property. In the static constructor, a new *InputGesturesCollection* is created and a key gesture is added to the collection. This collection is then used to initialize the instance of *RoutedUICommand* that is returned through the read-only property.

Using Custom Commands in XAML

Once you have created a custom command, you are ready to use it in code. If you want to use it in XAML, however, you also must map the namespace that contains the custom command to a XAML namespace. The following procedure describes how to use a custom command in XAML.

▶ **To use a custom command in XAML**

1. Create your custom command, as described previously.
2. Add a namespace mapping to your *Window* XAML. The following example demonstrates how to map a namespace called *WpfApplication13.CustomCommands*. Note that in this example, that would mean that your custom commands are kept in a separate namespace:

```
<Window x:Class="Window1"
   xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
   xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
   xmlns:CustomCommands="clr-namespace:WpfApplication13.CustomCommands"
   Title="Window1" Height="300" Width="300">


   <!-The rest of the XAML is omitted-->
</Window>
```

3. Use the newly mapped XAML namespace in your XAML code, as shown here:

```
<Button Command="CustomCommands:MyCommands.Launch" Height="23"
HorizontalAlignment="Left" Margin="60,91,0,0" Name="Button1" VerticalAlignment="Top"
Width="75">Button</Button>
```

Lab: Creating a Custom Command

In this lab, you create a custom command and then connect your command to UI elements by using a *CommandBinding*.

Exercise 1: Creating a Custom Command

1. From the CD, open the partial solution for this exercise.
2. From the Project menu, choose Add Class (in C#) or Add Module (in Visual Basic). Name the new item *CustomCommands* and click OK. Set the access modifier of this class or module to *public*.
3. If you are working in C#, add the following *using* statement to your class:

```
using System.Windows.Input;
```

   Otherwise, go on to Step 4.

4. Add a read-only property named *Launch* and a corresponding member variable that returns an instance of a *RoutedUICommand,* as shown here. (Note that these should be static members in C#.)

```
' VB
Private launch_command As RoutedUICommand
Public ReadOnly Property Launch() As RoutedUICommand
   Get
      Return launch_command
   End Get
End Property

// C#
private static RoutedUICommand launch_command;
public static RoutedUICommand Launch
{
   get
   {
      return launch_command;
   }
}
```

5. Add a constructor to your module (in Visual Basic) or a static constructor to your class (in C#) that creates a new *InputGestureCollection,* adds an appropriate input gesture to be associated with this new command, and then initializes the member variable that returns the custom command, as shown here:

```
' VB
Sub New()
   Dim myInputGestures As New InputGestureCollection
   myInputGestures.Add(New KeyGesture(Key.L, ModifierKeys.Control))
   launch_command = New RoutedUICommand("Launch", "Launch", _
      GetType(CustomCommands), myInputGestures)
End Sub

// C#
static CustomCommands()
{
   InputGestureCollection myInputGestures = new
      InputGestureCollection();
   myInputGestures.Add(new KeyGesture(Key.L, ModifierKeys.Control));
   launch_command = new RoutedUICommand("Launch", "Launch",
      typeof(CustomCommands), myInputGestures);
}
```

6. From the Build menu, choose Build Solution to build your solution.

Exercise 2: Using Your Custom Command

1. In XAML view, add the following code to your *Window* markup to create a reference to the class that contains your custom command:

   ```
   xmlns:Local="clr-namespace:YourProjectNamespaceGoesHere"
   ```

   The previous code in bold should be replaced with the namespace name of your project.

2. In XAML view, add the following attribute to both your *Button* control and your *Launch* MenuItem:

   ```
   Command="Local:CustomCommands.Launch"
   ```

3. In the *Window1* code view, add the following method:

   ```
   ' VB
   Private Sub Launch_Handler(ByVal sender As Object, _
      ByVal e As ExecutedRoutedEventArgs)
      MessageBox.Show("Launch invoked")
   End Sub

   // C#
   private void Launch_Handler(object sender, ExecutedRoutedEventArgs e)
   {
      MessageBox.Show("Launch invoked");
   }
   ```

4. From the Toolbox, drag a *CheckBox* control onto the form. Set the content of the control to "Enable Launch Command".

5. In the code view for *Window1*, add the following method:

   ```
   ' VB
   Private Sub LaunchEnabled_Handler(ByVal sender As Object, _
      ByVal e As CanExecuteRoutedEventArgs)
      e.CanExecute = CheckBox1.IsChecked
   End Sub

   // C#
   private void LaunchEnabled_Handler(object sender,
      CanExecuteRoutedEventArgs e)
   {
      e.CanExecute = (bool)checkBox1.IsChecked;
   }
   ```

6. Create or replace the constructor for *Window1* that creates and registers a *CommandBinding* for the *Launch* command. This *CommandBinding* should bind the *Launch.Executed* event to the *Launch_Handler* method and bind the *Launch.CanExecute* event to the *LaunchEnabled_Handler* method. An example is shown here:

```
' VB
Public Sub New()
   InitializeComponent()
   Dim abinding As New CommandBinding()
   abinding.Command = CustomCommands.Launch
   AddHandler abinding.Executed, AddressOf Launch_Handler
   AddHandler abinding.CanExecute, AddressOf LaunchEnabled_Handler
   Me.CommandBindings.Add(abinding)
End Sub

// C#
public Window1()
{
   InitializeComponent();
   CommandBinding abinding = new CommandBinding();
   abinding.Command = CustomCommands.Launch;
   abinding.Executed += new ExecutedRoutedEventHandler(Launch_Handler);
   abinding.CanExecute += new
      CanExecuteRoutedEventHandler(LaunchEnabled_Handler);
   this.CommandBindings.Add(abinding);
}
```

7. Press F5 to build and run your application. Note that when the application starts, the *Button* and *Launch* menu item are disabled. Select the check box to enable the command. Now you can invoke the command from the button, from the menu, or by using the Ctrl+L input gesture.

Lesson Summary

- Commands provide a central architecture for managing high-level tasks. The .NET Framework provides a library of built-in commands that map to common tasks that can be used in your applications.
- Commands can be invoked directly, by an input gesture such as a *MouseGesture* or a *KeyGesture*, or by activating a custom control. A single command can be associated with any number of gestures or controls.
- *CommandBindings* associate commands with command handlers. You can specify a method to handle the *Executed* event of a command and another method to handle the *CanExecute* event of a command.
- Methods handling the *CanExecute* event of a command should set the *CanExecute* property of the *CanExecuteRoutedEventArgs* to False when the command should be disabled.
- Commands can be bound by any number of *CommandBindings*. Commands exhibit bubbling behavior. When invoked, commands first look for a binding in

the collection of the element that the command was invoked in, and then look in each higher element in the visual tree.

- You can create custom commands. When you have created a custom command, you must map the namespace in which it exists to a XAML namespace in your XAML view.

Lesson Review

You can use the following questions to test your knowledge of the information in Lesson 2, "Configuring Commands." The questions are also available on the companion CD if you prefer to review them in electronic form.

NOTE Answers

Answers to these questions and explanations of why each answer choice is correct or incorrect are located in the "Answers" section at the end of the book.

---

1. Which of the following is required to bind a command to a command handler? (Choose all that apply.)
   - **A.** Instantiate a new instance of *CommandBinding*
   - **B.** Set the *CommandBinding.Command* property to a command
   - **C.** Add one or more input gestures to your command
   - **D.** Add a handler for the *CommandBinding.Executed* event
   - **E.** Add a handler for the *CommandBinding.CanExecute* event
   - **F.** Add *CommandBinding* to the *CommandBindings* collection of the *Window* or other control associated with the command
2. You are working with an application that exposes a command named *Launch*. This command is registered in the *CommandBindings* collection of a control called *Window11* and requires a *String* parameter. Which of the following code snippets invokes the command from code correctly?
   - **A.**

```
' VB
Launch.CanExecute = True
Launch.Execute("Boom", Window11)

// C#
Launch.CanExecute = true;
Launch.Execute("Boom", Window11);
```

B.

```
' VB
Launch.Execute("Boom")

// C#
Launch.Execute("Boom");
```

C.

```
' VB
Launch.Execute("Boom", Window11)

// C#
Launch.Execute("Boom", Window11);
```

D.

```
' VB
Window11.CanExecute(Launch, True)
Launch.Execute("Boom", Window11)

// C#
Window11.CanExecute(Launch, true);
Launch.Execute("Boom", Window11);
```

Lesson 3: Configuring Application Settings

The .NET Framework allows you to create and access values that persist from application session to application session. The values are called *settings*. Settings can represent any kind of information that an application might need from session to session, such as user preferences, the address of a Web server, or any other kind of necessary information. In this lesson, you will learn to create and access settings. You will learn the difference between a user setting and an application setting, and you will learn to load and save settings at run time.

After this lesson, you will be able to:

- Explain the difference between a user setting and an application setting
- Create a new setting at design time
- Load settings at run time
- Save user settings at run time

Estimated lesson time: 15 minutes

Settings can be used to store information that is valuable to the application but might change from time to time. For example, you can use settings to store user preferences, such as the color scheme of an application, or the address of a Web server used by the application.

Settings have four properties:

- *Name,* which indicates the name of the setting. This is used to access the setting at run time.
- *Type,* which represents the data type of the setting.
- *Value,* which is the value returned by the setting.
- *Scope,* which can be either *User* or *Application*.

The *Name, Type,* and *Value* properties should be fairly self-explanatory. The *Scope* property, however, bears a little closer examination. The *Scope* property can be set to either *Application* or *User*. A setting with *Application* scope represents a value that is used by the entire application regardless of the user, whereas an application with *User* scope is more likely to be user-specific and less crucial to the application.

An important distinction between user settings and application settings is that user settings are read/write. They can be read and written to at run time, and newly written

values can be saved by the application. In contrast, *Application settings* are read-only and the values can be changed only at design time or by editing the Settings file between application sessions.

Creating Settings at Design Time

Visual Studio provides an editor to create settings for your application at design time. This editor is shown in Figure 2-1.

Figure 2-1 The Settings Editor

The Settings Editor allows you to create new settings and set each of their four properties. The *Name* property, the name that you use to retrieve the setting value, must be unique in the application. The *Type* property represents the type of the setting. The *Scope* property is either *Application*, which represents a read-only property, or *User*, which represents a read-write setting. Finally, the *Value* property represents the value returned by the setting. The *Value* property must be of the type specified by the Type property.

▶ To create a setting at design time

1. If you are working in C#, in Solution Explorer, under Properties, locate and double-click Settings.settings to open the Settings Editor. If you are working in Visual Basic, in Solution Explorer, double-click MyProject and select the Settings tab.
2. Set the Name, Type, Scope, and Value for the new setting.
3. If your application has not yet been saved, choose Save All from the File menu to save your application.

Loading Settings at Run Time

At run time, you can access the values contained by the settings. In Visual Basic, settings are exposed through the *My* object, whereas in C#, you access settings through the *Properties.Settings.Default* object. At design time, individual settings appear in IntelliSense as properties of the *Settings* object and can be treated in code as such. Settings are strongly typed and are retrieved as the same type as specified when they were created. The following example code demonstrates how to copy the value from a setting to a variable:

```
' VB
Dim aString As String
aString = My.Settings.MyStringSetting

// C#
String aString;
aString = Properties.Settings.Default.MyStringSetting;
```

Saving User Settings at Run Time

You can save the value of user settings at run time. To change the value of a user setting, simply assign it a new value, just as you would any property or field. Then you must call the *Save* method to save the new value. An example is shown here:

```
' VB
My.Settings.Headline = "This is tomorrow's headline"
My.Settings.Save

// C#
Properties.Settings.Default.Headline = "This is tomorrow's headline";
Properties.Settings.Default.Save();
```

Quick Check

- What is the difference between a user setting and an application setting?

Quick Check Answer

- A user setting is designed to be user-specific, such as a background color. User settings can be written at run time and can vary from user to user. An application setting is designed to be constant for all users of an application, such as a database connection string. Application settings are read-only at run time.

Lab: Practice with Settings

In this lab you create an application that uses settings. You define settings while building the application, read the settings, apply them in your application, and enable the user to change one of the settings.

Exercise: Using Settings

1. In Visual Studio, create a new WPF application.
2. In Solution Explorer, expand Properties and double-click Settings.settings (in C#) or double-click My Project and choose the Settings tab (in Visual Basic) to open the Settings Editor.
3. Add two settings, as described in this table:

Name	Type	Scope	Value
ApplicationName	*String*	Application	Settings App
BackgroundColor	*System.Windows.Media.Color*	User	#ff0000ff

   Note that you will have to browse to find the *System.Windows.Media* type, then expand the node to find the *System.Windows.Media.Color* type.

4. In XAML view, add the following XAML to the *Grid* element to add a *ListBox* with four items and a *Button* to your user interface:

```
<ListBox Margin="15,15,0,0" Name="listBox1" Height="78"
   HorizontalAlignment="Left" VerticalAlignment="Top" Width="107">
   <ListBoxItem>Red</ListBoxItem>
   <ListBoxItem>Blue</ListBoxItem>
   <ListBoxItem>Green</ListBoxItem>
   <ListBoxItem>Tomato</ListBoxItem>
</ListBox>
<Button Margin="15,106,110,130" Name="button1">Change Background
   Color</Button>
```

5. In the designer, double-click *button1* to open the code view to the default handler for the *Click* event. Add the following code:

```
' VB
If Not listBox1.SelectedItem Is Nothing Then
   Dim astring As String = CType(listBox1.SelectedItem, _
      ListBoxItem).Content.ToString
   Select Case astring
      Case "Red"
         My.Settings.BackgroundColor = Colors.Red
```

```
      Case "Blue"
         My.Settings.BackgroundColor = Colors.Blue
      Case "Green"
         My.Settings.BackgroundColor = Colors.Green
      Case "Tomato"
         My.Settings.BackgroundColor = Colors.Tomato
   End Select
   Me.Background = New _
      System.Windows.Media.SolidColorBrush(My.Settings.BackgroundColor)
   My.Settings.Save()
End If

// C#
if (!(listBox1.SelectedItem == null))
{
   String astring =
      ((ListBoxItem)listBox1.SelectedItem).Content.ToString();
   switch (astring)
   {
      case "Red":
         Properties.Settings.Default.BackgroundColor = Colors.Red;
         break;
      case "Blue":
         Properties.Settings.Default.BackgroundColor = Colors.Blue;
         break;
      case "Green":
         Properties.Settings.Default.BackgroundColor = Colors.Green;
         break;
      case "Tomato":
         Properties.Settings.Default.BackgroundColor = Colors.Tomato;
         break;
   }
   this.Background = new
      System.Windows.Media.SolidColorBrush(
         Properties.Settings.Default.BackgroundColor);
   Properties.Settings.Default.Save();
}
```

6. Create or replace the constructor for this class with the following code to read and apply the settings:

```
' VB
Public Sub New()
   InitializeComponent()
   Me.Title = My.Settings.ApplicationName
   Me.Background = New _
      System.Windows.Media.SolidColorBrush(My.Settings.BackgroundColor)
End Sub

// C#
public Window1()
{
   InitializeComponent();
```

```
    this.Title = Properties.Settings.Default.ApplicationName;
    this.Background = new
        System.Windows.Media.SolidColorBrush(
            Properties.Settings.Default.BackgroundColor);
}
```

7. Press F5 to build and run your application. Note that the title of the window is the value of your *ApplicationName* setting and the background color of your window is the value indicated by the *BackgroundColor* setting. You can change the background color by selecting an item in the *ListBox* and clicking the button. After changing the background color, close the application and restart it. Note that the background color of the application at startup is the same as it was when the previous application session ended.

Lesson Summary

- Settings allow you to persist values between application sessions. You can add new settings at design time by using the Settings Editor.
- Settings can be one of two different scopes. Settings with Application scope are read-only at run time and can be changed only by altering the Settings file between application sessions. Settings with User scope are read-write at run time.
- You can access settings in code through *My.Settings* in Visual Basic, or *Properties.Settings.Default* in C#.

Lesson Review

You can use the following questions to test your knowledge of the information in Lesson 3, "Configuring Application Settings." The questions are also available on the companion CD if you prefer to review them in electronic form.

NOTE Answers

Answers to these questions and explanations of why each answer choice is correct or incorrect are located in the "Answers" section at the end of the book.

---

1. Which of the following code snippets correctly sets the value of a setting called *Title* and persists it?

   A.

```
' VB
My.Settings("Title") = "New Title"
My.Settings.Save
```

```
// C#
Properties.Settings.Default["Title"] = "New Title";
Properties.Settings.Default.Save();
```

B.

```
' VB
My.Settings("Title") = "New Title"

// C#
Properties.Settings.Default["Title"] = "New Title";
```

C.

```
' VB
My.Settings.Title = "New Title"
My.Settings.Save()

// C#
Properties.Settings.Default.Title = "New Title";
Properties.Settings.Default.Save();
```

D.

```
' VB
My.Settings.Title = "New Title"

// C#
Properties.Settings.Default.Title = "New Title";
```

2. Which of the following code snippets reads a setting of type *System.Windows.Media.Color* named *MyColor* correctly?

A.

```
' VB
Dim aColor As System.Windows.Media.Color
aColor = CType(My.Settings.MyColor, System.Windows.Media.Color)

// C#
System.Windows.Media.Color aColor;
aColor = (System.Windows.Media.Color)Properties.Settings.Default.MyColor;
```

B.

```
' VB
Dim aColor As System.Windows.Media.Color
aColor = My.Settings.MyColor.ToColor()

// C#
System.Windows.Media.Color aColor;
aColor = Properties.Settings.Default.MyColor.ToColor();
```

C.

```
' VB
Dim aColor As Object
aColor = My.Settings.MyColor

// C#
Object aColor;
aColor = Properties.Settings.Default.MyColor;
```

D.

```
' VB
Dim aColor As System.Windows.Media.Color
aColor = My.Settings.MyColor

// C#
System.Windows.Media.Color aColor;
aColor = Properties.Settings.Default.MyColor;
```

Chapter Review

To practice and reinforce the skills you learned in this chapter further, you can do any or all of the following:

- Review the chapter summary.
- Review the list of key terms introduced in this chapter.
- Complete the case scenarios. These scenarios set up real-world situations involving the topics of this chapter and ask you to create a solution.
- Complete the suggested practices.
- Take a practice test.

Chapter Summary

- Routed events can be raised by multiple UI elements in the visual tree. Bubbling events are raised first by the element in which they originate and then bubble up through the visual tree. Tunneling events are raised first by the topmost element in the visual tree and tunnel down to the element in which the event originates. Direct events are raised only by the element in which they originate.
- Elements in the visual tree can handle events that they do not themselves define. These are called *attached events*. You can define a handler for an attached event in the XAML that defines the element.
- You can use the *EventManager* class to register a new routed event and to register a class event handler.
- Commands provide an architecture that allows you to define high-level tasks, connect those tasks to a variety of inputs, define handlers that execute code when commands are invoked, and determine when a command is unavailable.
- You can use the built-in library of commands or create custom commands for your application. Commands can be triggered by controls, input gestures, or direct invocation.
- The *CommandBinding* object binds commands to command handlers.
- Settings allow you to create applications that persist between application sessions. Application scope settings are read-only at run time, and user scope settings are read-write at run time.
- Settings are exposed as strongly typed properties on the *My.Settings* object (in Visual Basic) and the *Properties.Settings.Default* object (in C#).

Key Terms

Do you know what these key terms mean? You can check your answers by looking up the terms in the glossary at the end of the book.

- Application Setting
- Bubbling Event
- Command
- Command Handler
- Direct Event
- Event Handler
- Gesture
- Routed Event
- Setting
- Tunneling Event
- User Setting

Case Scenarios

In the following case scenarios, you will apply what you've learned about how to use commands, events, and settings to design user interfaces. You can find answers to these questions in the "Answers" section at the end of this book.

Case Scenario 1: Validating User Input

You're creating a form that will be used by Humongous Insurance data entry personnel to input data. The form consists of several *TextBox* controls that receive input. Data entry is expected to proceed quickly and without errors, but to help ensure this you will be designing validation for this form. This validation is somewhat complex—there is a set of characters that is not allowed in any text box on the form, and each text box has additional limitations that differ from control to control. You would like to implement this validation scheme with a minimum of code in order to make troubleshooting and maintenance simple.

Question

Answer the following question for your manager:

- What strategies can we use to implement these requirements?

Case Scenario 2: Humongous Insurance User Interface

The front end for this database is just as complex as the validation requirements. You are faced with a front end that exposes many menu options. Furthermore, for expert users, some of the more commonly used menu items can be triggered by holding down the Ctrl key while performing various gestures with the mouse. Functionality invoked by the menu items sometimes will be unavailable. Finally, you need to allow the operator to edit data in this window quickly and easily.

Technical Requirements

- All main menu items must have access keys, and some have mouse shortcuts.
- Availability of menu items must be communicated to the user in a way that is easy to understand but does not disrupt program flow.
- You must ensure that when a menu item is unavailable, corresponding shortcut keys and mouse gestures are also inactivated.
- Certain *TextBox* controls on the form must fill in automatically when appropriate keystrokes are entered.

Question

- How can this functionality be implemented?

Suggested Practices

- Create a rudimentary text editor with buttons that implement the Cut, Copy, and Paste commands.
- Create an application that stores a color scheme for each user and automatically loads the correct color scheme when the user opens the application.
- Build an application that consists of a window with a single button that the user can chase around the window with the mouse but can never actually click.

Take a Practice Test

The practice tests on this book's companion CD offer many options. For example, you can test yourself on just the content covered in this chapter, or you can test yourself on all the 70-502 certification exam content. You can set up the test so that it closely simulates the experience of taking a certification exam, or you can set it up in study mode so that you can look at the correct answers and explanations after you answer each question.

MORE INFO Practice tests

For details about all the practice test options available, see the section "How to Use the Practice Tests," in this book's Introduction.

Chapter 7

Styles and Animation

One of the major advances with the advent of the Windows Presentation Foundation (WPF) programming model is the uniquely agile use of the system's visual capabilities. In this chapter, you learn to use two aspects of WPF programming that take full advantage of these capabilities: styles and animation. Styles allow you to quickly apply changes to the visual interface and change the look and feel of your application in response to different conditions. Animations allow you to change property values over timelines that can be useful for a variety of visual effects. Together, these features allow you to harness the full power of the WPF presentation layer.

Exam objectives in this chapter:

- Create a consistent user interface appearance by using styles.
- Change the appearance of a UI element by using triggers.
- Add interactivity by using animations.

Lessons in this chapter:

- Lesson 1: Styles 305
- Lesson 2: Animations 323

Before You Begin

To complete the lessons in this chapter, you must have

- A computer that meets or exceeds the minimum hardware requirements listed in the "About This Book" section at the beginning of the book
- Microsoft Visual Studio 2008 Professional Edition installed on your computer
- An understanding of Microsoft Visual Basic or C# syntax and familiarity with Microsoft .NET Framework version 3.5
- An understanding of Extensible Application Markup Language (XAML)

Real World

Matthew Stoecker

At every turn, it seems that WPF provides more and more support for the creation of rich visual interfaces. The support for styles and triggers enables the rapid creation of interactive visual interfaces that used to take hours of coding event handlers. Likewise, animations now open up the possibilities for stunning user interfaces with minimal effort. I'm glad that now I can create attractive applications with the same amount of effort that the boxy old Windows Forms apps took!

Lesson 1: Styles

Styles allow you to create a cohesive look and feel for your application. You can use styles to define a standard color and sizing scheme for your application and use triggers to provide dynamic interaction with your UI elements. In this lesson, you learn to create and implement styles. You learn to apply a style to all instances of a single type and to implement style inheritance. You learn to use setters to set properties and event handlers, and you learn to use triggers to change property values dynamically. Finally, you learn about the order of property precedence.

After this lesson, you will be able to:

- Create and implement a style
- Apply a style to all instances of a type
- Implement style inheritance
- Use property and event setters
- Explain the order of property value precedence
- Use and implement triggers, including property triggers, data triggers, event triggers, and multiple triggers

Estimated lesson time: 30 minutes

Using Styles

Styles can be thought of as analogous to cascading style sheets as used in Hypertext Markup Language (HTML) pages. Styles basically tell the presentation layer to substitute a new visual appearance for the standard one. They allow you to make changes to the user interface as a whole easily and to provide a consistent look and feel for your application in a variety of situations. Styles enable you to set properties and hook up events on UI elements through the application of those styles. Further, you can create visual elements that respond dynamically to property changes through the application of triggers, which listen for a property change and then apply style changes in response.

Properties of Styles

The primary class in the application of styles is, unsurprisingly, the *Style* class. The *Style* class contains information about styling a group of properties. A *Style* can be created to

apply to a single instance of an element, to all instances of an element type, or across multiple types. The important properties of the *Style* class are shown in Table 7-1.

Table 7-1 Important Properties of the *Style* Class

Property	Description
BasedOn	Indicates another style that this style is based on. This property is useful for creating inherited styles.
Resources	Contains a collection of local resources used by the style. The *Resources* property is discussed in detail in Chapter 9, "Resources, Documents, and Localization."
Setters	Contains a collection of *Setter* or *EventSetter* objects. These are used to set properties or events on an element as part of a style.
TargetType	This property identifies the intended element type for the style.
Triggers	Contains a collection of *Trigger* objects and related objects that allow you to designate a change in the user interface in response to changes in properties.

The basic skeleton of a <*Style*> element in XAML markup looks like the following:

```
<Style>
   <!-- A collection of setters is enumerated here -->
   <Style.Triggers>
   <!-- A collection of Trigger and related objects is enumerated here -->
   </Style.Triggers>
   <Style.Resources>
      <!-- A collection of local resources for use in the style -->
   </Style.Resources>
</Style>
```

Setters

The most common class you will use in the construction of Styles is the *Setter*. As their name implies, *Setters* are responsible for setting some aspect of an element. *Setters* come in two flavors: property setters (or just *Setters*, as they are called in markup), which set values for properties; and event setters, which set handlers for events.

Property Setters

Property setters, represented by the <*Setter*> tag in XAML, allow you to set properties of elements to specific values. A property setter has two important properties: the *Property* property, which designates the property that is to be set by the *Setter,* and the *Value* property, which indicates the value to which the property is to be set. The following example demonstrates a *Setter* that sets the Background property of a *Button* element to *Red:*

```
<Setter Property="Button.Background" Value="Red" />
```

The value for the *Property* property must take the form of the following:

```
Element.PropertyName
```

If you want to create a style that sets a property on multiple different types of elements, you could set the style on a common class that the elements inherit, as shown here:

```
<Style>
   <Setter Property="Control.Background" Value="Red" />
</Style>
```

This style sets the *Background* property of all elements that inherit from the *Control* to which it is applied.

Event Setters

Event setters (represented by the <*EventSetter*> tag) are similar to property setters, but they set event handlers rather than property values. The two important properties for an *EventSetter* are the *Event* property, which specifies the event for which the handler is being set; and the *Handler* property, which specifies the event handler to attach to that event. An example is shown here:

```
<EventSetter Event="Button.MouseEnter" Handler="Button_MouseEnter" />
```

The value of the *Handler* property must specify an extant event handler with the correct signature for the type of event with which it is connected. Similar to property setters, the format for the *Event* property is

```
Element.EventName
```

where the element type is specified, followed by the event name.

Creating a Style

You've seen the simplest possible implementation of a style: a single *Setter* between two *Style* tags, but you haven't yet seen how to apply a style to an element. There are several ways to apply a style to an element or elements. This section examines the various ways to apply a style to elements in your user interface.

Setting the *Style* Property Directly

The most straightforward way to apply a style to an element is to set the *Style* property directly in XAML. The following example demonstrates directly setting the *Style* property of a *Button* element:

```
<Button Height="25" Name="Button1" Width="100">
   <Button.Style>
      <Style>
         <Setter Property="Button.Content" Value="Style set directly" />
         <Setter Property="Button.Background" Value="Red" />
      </Style>
   </Button.Style>
</Button>
```

While setting the *Style* directly in an element might be the most straightforward, it is seldom the best method. When setting the *Style* directly, you must set it for each element that you want to be affected by the *Style*. In most cases, it is simpler to set the properties of the element directly at design time.

One scenario where you might want to set the *Style* directly on an element is to provide a set of *Triggers* for that element. Because *Triggers* must be set in a *Style* (except for *EventTriggers*, as you will see in the next section), you conceivably could set the *Style* directly to set triggers for an element.

Setting a Style in a *Resources* Collection

The most common method for setting styles is to create the style as a member of a *Resources* collection and then apply the style to elements in your user interface by referencing the resource. The following example demonstrates creating a style as part of the *Windows.Resources* collection:

```
<Window.Resources>
   <Style x:Key="StyleOne">
      <Setter Property="Button.Content" Value="Style defined in resources" />
      <Setter Property="Button.Background" Value="Red" />
   </Style>
</Window.Resources>
```

Under most circumstances, you must supply a key value for a *Style* that you define in the *Resources* collection. Then you can apply that style to an element by referencing the resource, as shown in bold here:

```
<Button Name="Button1" Style="{StaticResource StyleOne}" Height="30"
   Width="200" />
```

The advantage to defining a *Style* in the *Resources* section is that you can then apply that *Style* to multiple elements by simply referencing the resource. Resources are discussed in detail in Chapter 9.

Applying Styles to All Controls of a Specific Type

You can use the *TargetType* property to specify a type of element to be associated with the style. When you set the *TargetType* property on a *Style,* that *Style* is applied to all elements of that type automatically. Further, you do not need to specify the qualifying type name in the *Property* property of any *Setters* that you use—you can just refer to the property name. When you specify the *TargetType* for a *Style* that you have defined in a *Resources* collection, you do not need to provide a key value for that style. The following example demonstrates the use of the *TargetType* property:

```
<Window.Resources>
   <Style TargetType="Button">
      <Setter Property=" Content" Value="Style set for all buttons" />
      <Setter Property="Background" Value="Red" />
   </Style>
</Window.Resources>
```

When you apply the *TargetType* property, you do not need to add any additional markup to the elements of that type to apply the style.

If you want an individual element to opt out of the style, you can set the style on that element explicitly, as seen here:

```
<Button Style="{x:Null}" Margin="10">No Style</Button>
```

This example explicitly sets the *Style* to *Null,* which causes the *Button* to revert to its default look. You also can set the *Style* to another *Style* directly, as seen earlier in this lesson.

Setting a Style Programmatically

You can create and define a style programmatically. While defining styles in XAML is usually the best choice, creating a style programmatically might be useful when you want to create and apply a new style dynamically, possibly based on user preferences.

The typical method for creating a style programmatically is to create the *Style* object in code; then create *Setters* (and *Triggers*, if appropriate); add them to the appropriate collection on the *Style* object; and then when finished, set the *Style* property on the target elements. The following example demonstrates creating and applying a simple style in code:

```
' VB
Dim aStyle As New Style
Dim aSetter As New Setter
aSetter.Property = Button.BackgroundProperty
aSetter.Value = Brushes.Red
aStyle.Setters.Add(aSetter)
Dim bSetter As New Setter
bSetter.Property = Button.ContentProperty
bSetter.Value = "Style set programmatically"
aStyle.Setters.Add(bSetter)
Button1.Style = aStyle

// C#
Style aStyle = new Style();
Setter aSetter = new Setter();
aSetter.Property = Button.BackgroundProperty;
aSetter.Value = Brushes.Red;
aStyle.Setters.Add(aSetter);
Setter bSetter = new Setter();
bSetter.Property = Button.ContentProperty;
bSetter.Value = "Style set programmatically";
aStyle.Setters.Add(bSetter);
Button1.Style = aStyle;
```

You can also define a style in a *Resources* collection and apply that style in code, as shown here:

```
<!-- XAML -->
<Window.Resources>
   <Style x:Key="StyleOne">
      <Setter Property="Button.Content" Value="Style applied in code" />
      <Setter Property="Button.Background" Value="Red" />
   </Style>
</Window.Resources>

' VB
Dim aStyle As Style
aStyle = CType(Me.Resources("StyleOne"), Style)
Button1.Style = aStyle

// C#
Style aStyle;
aStyle = (Style)this.Resources["StyleOne"];
Button1.Style = aStyle;
```

Implementing Style Inheritance

You can use inheritance to create styles that conform to the basic look and feel of the original style but provide differences that offset some controls from others. For example, you might create one *Style* for all the *Button* elements in your user interface and create an inherited style to provide emphasis for one of the buttons. You can use the *BasedOn* property to create *Style* objects that inherit from other *Style* objects. The *BasedOn* property references another style and automatically inherits all the members of that *Style* and then allows you to build on that *Style* by adding additional members. The following example demonstrates two *Style* objects—an original *Style* and a *Style* that inherits it:

```
<Window.Resources>
   <Style x:Key="StyleOne">
      <Setter Property="Button.Content" Value="Style set in original Style" />
      <Setter Property="Button.Background" Value="Red" />
      <Setter Property="Button.FontSize" Value="15" />
      <Setter Property="Button.FontFamily" Value="Arial" />
   </Style>
   <Style x:Key="StyleTwo" BasedOn="{StaticResource StyleOne}">
      <Setter Property="Button.Content" Value="Style set by inherited style" />
      <Setter Property="Button.Background" Value="AliceBlue" />
      <Setter Property="Button.FontStyle" Value="Italic" />
   </Style>
</Window.Resources>
```

The result of applying these two styles is seen in Figure 7-1.

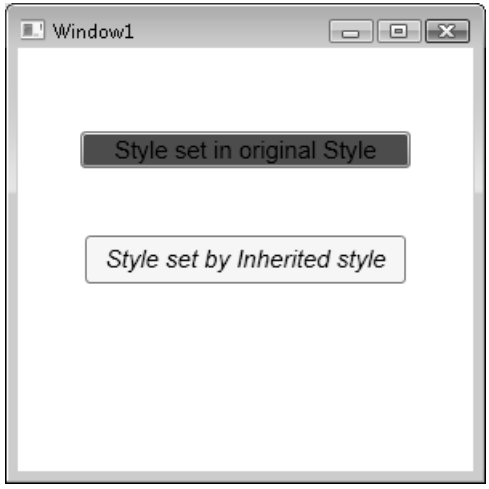

Figure 7-1 Two buttons—the original and an inherited style

When a property is set in both the original style and the inherited style, the property value set by the inherited style always takes precedence. But when a property is set by the original style and not set by the inherited style, the original property setting is retained.

Quick Check

- Under what circumstances is a *Style* automatically applied to an element? How else can a *Style* be applied to an element?

Quick Check Answer

- A *Style* is applied to an element automatically when it is declared as a resource in the page and the *TargetType* property of the *Style* is set. If the *TargetType* property is not set, you can apply a *Style* to an element by setting that element's *Style* property, either in XAML or in code.

Triggers

Along with *Setters*, *Triggers* make up the bulk of objects that you use in creating styles. *Triggers* allow you to implement property changes declaratively in response to other property changes that would have required event-handling code in Windows Forms programming. There are five kinds of *Trigger* objects, as listed in Table 7-2.

Table 7-2 Types of *Trigger* Objects

Type	Class Name	Description
Property trigger	*Trigger*	Monitors a property and activates when the value of that property matches the *Value* property.
Multi-trigger	*MultiTrigger*	Monitors multiple properties and activates only when all the monitored property values match their corresponding *Value* properties.
Data trigger	*DataTrigger*	Monitors a bound property and activates when the value of the bound property matches the *Value* property.

Table 7-2 Types of *Trigger* Objects

Type	Class Name	Description
Multi-data-trigger	*MultDataTrigger*	Monitors multiple bound properties and activates only when all the monitored bound properties match their corresponding *Value* properties.
Event trigger	*EventTrigger*	Initiates a series of *Actions* when a specified event is raised.

A *Trigger* is active only when it is part of a *Style.Triggers* collection—with one exception. *EventTrigger* objects can be created within a *Control.Triggers* collection outside a *Style*. The *Control.Triggers* collection can accommodate only *EventTriggers*, and any other *Trigger* placed in this collection causes an error. *EventTriggers* are primarily used with animation and are discussed further in Lesson 2 of this chapter, "Animations."

Property Triggers

The most commonly used type of *Trigger* is the property trigger. The property trigger monitors the value of a property specified by the *Property* property. When the value of the specified property equals the *Value* property, the *Trigger* is activated. Important properties of property triggers are shown in Table 7-3.

Table 7-3 Important Properties of Property Triggers

Property	Description
EnterActions	Contains a collection of *Action* objects that are applied when the *Trigger* becomes active. Actions are discussed in greater detail in Lesson 2 of this chapter.
ExitActions	Contains a collection of *Action* objects that are applied when the *Trigger* becomes inactive. *Actions* are discussed in greater detail in Lesson 2 of this chapter.
Property	Indicates the property that is monitored for changes.
Setters	Contains a collection of *Setter* objects that are applied when the *Trigger* becomes active.
Value	Indicates the value that is compared to the property referenced by the *Property* property.

Triggers listen to the property indicated by the *Property* property and compare that property to the *Value* property. When the referenced property and the *Value* property are equal, the *Trigger* is activated. Any *Setter* objects in the *Setters* collection of the *Trigger* are applied to the style, and any *Actions* in the *EnterActions* collections are initiated. When the referenced property no longer matches the *Value* property, the *Trigger* is inactivated. All *Setter* objects in the *Setters* collection of the *Trigger* are inactivated, and any *Actions* in the *ExitActions* collection are initiated.

NOTE *Actions* are used primarily in animations, and they are discussed in greater detail in Lesson 2 of this chapter.

The following example demonstrates a simple *Trigger* object that changes the *FontWeight* of a *Button* element to *Bold* when the mouse enters the *Button:*

```
<Style.Triggers>
   <Trigger Property="Button.IsMouseOver" Value="True">
      <Setter Property="Button.FontWeight" Value="Bold" />
   </Trigger>
</Style.Triggers>
```

In this example, the *Trigger* defines one *Setter* in its *Setters* collection. When the *Trigger* is activated, that *Setter* is applied.

Multi-triggers

Multi-triggers are similar to property triggers in that they monitor the value of properties and activate when those properties meet a specified value. The difference is that multi-triggers are capable of monitoring several properties at a single time and they activate only when all monitored properties equal their corresponding *Value* properties. The properties that are monitored and their corresponding *Value* properties are defined by a collection of *Condition* objects. The following example demonstrates a *MultiTrigger* that sets the *Button.FontWeight* property to *Bold* only when the *Button* is focused and the mouse has entered the control:

```
<Style.Triggers>
   <MultiTrigger>
      <MultiTrigger.Conditions>
         <Condition Property="Button.IsMouseOver" Value="True" />
         <Condition Property="Button.IsFocused" Value="True" />
      </MultiTrigger.Conditions>
      <MultiTrigger.Setters>
         <Setter Property="Button.FontWeight" Value="Bold" />
      </MultiTrigger.Setters>
   </MultiTrigger>
</Style.Triggers>
```

Data Triggers and Multi-data-triggers

Data triggers are similar to property triggers in that they monitor a property and activate when the property meets a specified value, but they differ in that the property they monitor is a bound property. Instead of a *Property* property, data triggers expose a *Binding* property that indicates the bound property to listen to. The following shows a data trigger that changes the *Background* property of a *Label* to *Red* when the bound property *CustomerName* equals "Fabrikam":

```
<Style.Triggers>
   <DataTrigger Binding="{Binding Path=CustomerName}" Value="Fabrikam">
      <Setter Property="Label.Background" Value="Red" />
   </DataTrigger>
</Style.Triggers>
```

Multi-data-triggers are to data triggers as multi-triggers are to property triggers. They contain a collection of *Condition* objects, each of which specifies a bound property via its *Binding* property and a value to compare to that bound property. When all the conditions are satisfied, the *MultiDataTrigger* activates. The following example demonstrates a *MultiDataTrigger* that sets the *Label.Background* property to *Red* when *CustomerName* equals "Fabrikam" and *OrderSize* equals 500:

```
<Style.Triggers>
   <MultiDataTrigger>
      <MultiDataTrigger.Conditions>
         <Condition Binding="{Binding Path=CustomerName}" Value="Fabrikam" />
         <Condition Binding="{Binding Path=OrderSize}" Value="500" />
      </MultiDataTrigger.Conditions>
      <MultiDataTrigger.Setters>
         <Setter Property="Label.Background" Value="Red" />
      </MultiDataTrigger.Setters>
   </MultiDataTrigger>
</Style.Triggers>
```

Event Triggers

Event triggers are different from the other *Trigger* types. While other *Trigger* types monitor the value of a property and compare it to an indicated value, event triggers specify an event and activate when that event is raised. In addition, event triggers do not have a *Setters* collection—rather, they have an *Actions* collection. Although you have been exposed briefly to the *SoundPlayerAction* in Chapter 4, "Adding and Managing Content," most actions deal with animations, which are discussed in detail in Lesson 2 of this chapter. The following two examples demonstrate the *EventTrigger*

class. The first example uses a *SoundPlayerAction* to play a sound when a *Button* is clicked:

```
<EventTrigger RoutedEvent="Button.Click">
   <SoundPlayerAction Source="C:\myFile.wav" />
</EventTrigger>
```

The second example demonstrates a simple animation that causes the *Button* to grow in height by 200 units when clicked:

```
<EventTrigger RoutedEvent="Button.Click">
   <EventTrigger.Actions>
      <BeginStoryboard>
         <Storyboard>
            <DoubleAnimation Duration="0:0:5"
               Storyboard.TargetProperty="Height" To="200" />
         </Storyboard>
      </BeginStoryboard>
   </EventTrigger.Actions>
</EventTrigger>
```

Understanding Property Value Precedence

By now, you have probably noticed that a property can be set in many different ways. They can be set in code; they can be set by styles; they can have default values; and so on. It might seem logical at first to believe that a property will have the value it was last set to, but this is actually incorrect. There is a defined and strict order of precedence that determines a property's value based on *how* it was set, not when. The precedence order is summarized here, with highest precedence listed first:

1. Set by coercion by the property system.
2. Set by active animations or held animations.
3. Set locally, either by code, by direct setting in XAML, or through data binding.
4. Set by the *TemplatedParent*. Within this category, there is a sub-order of precedence, again listed in descending order:
   a. Set by *Triggers* from the templated parent
   b. Set by the templated parent through property sets
5. Implicit style—this applies only to the *Style* property.
6. Set by *Style* triggers.
7. Set by *Template* triggers.

8. Set by *Style* setters.
9. Set by the default *Style*. There is a sub-order within this category, again listed in descending order:
    a. Set by *Triggers* in the default style
    b. Set by *Setters* in the default style
10. Set by inheritance.
11. Set by metadata.

Exam Tip The order of property precedence seems complicated, but actually it is fairly logical. Be sure that you understand the concept behind the property order in addition to knowing the order itself.

This may seem like a complicated and arbitrary order of precedence, but upon closer examination it is actually very logical and based upon the needs of the application and the user. The highest precedence is property coercion. This takes place in some elements if an attempt is made to set a property beyond its allowed values. For example, if an attempt is made to set the *Value* property of a *Slider* control to a value higher than the *Maximum* property, the *Value* is coerced to equal the *Maximum* property. Next in precedence come animations. For animations to have any meaningful use, they must be able to override preset property values. The next highest level of precedence is properties that have been set explicitly through developer or user action.

Properties set by the *TemplatedParent* are next in the order of precedence. These are properties set on objects that come into being through a template. Templates are discussed further in Chapter 8, "Customizing the User Interface." After this comes a special precedence item that applies only to the *Style* property of an element: Provided that the *Style* property has not been set by any item with a higher-level precedence, it is set to a *Style* whose *TargetType* property matches the type of the element in question. Then come properties set by *Triggers*—first those set by a *Style,* then those set by a *Template*. This is logical because for triggers to have any meaningful effect, they must override properties set by styles.

Properties set by styles come next: first properties set by user-defined styles, and then properties set by the default style (also called the *Theme,* which typically is set by the operating system). Finally come properties that are set through inheritance and the application of metadata.

For developers, there are a few important implications that are not intuitively obvious. The most important is that if you set a property explicitly—whether in XAML or in code—the explicitly set property blocks any changes dictated by a *Style* or *Trigger*. WPF assumes that you want that property value to be there for a reason and does not allow it to be set by a *Style* or *Trigger,* although it still can be overridden by an active animation.

A second, less obvious implication is that when using the Visual Studio designer to drag and drop items onto the design surface from the *ToolBox,* the designer explicitly sets several properties, especially layout properties. These property settings have the same precedence as they would if you had set them yourself. So if you are designing a style-oriented user interface, you should either enter XAML code directly in XAML view to create controls and set as few properties explicitly as possible, or you should review the XAML that Visual Studio generates and delete settings as appropriate.

You can clear a property value that has been set in XAML or code manually by calling the *DependencyObject.ClearValue* method. The following code example demonstrates how to clear the value of the *Width* property on a button named *Button1*:

```
' VB
Button1.ClearValue(WidthProperty)

// C#
Button1.ClearValue(WidthProperty);
```

Once the value has been cleared, it can be reset automatically by the property system.

Lab: Creating High-Contrast Styles

In this lab, you create a rudimentary high-contrast *Style* for *Button, TextBox,* and *Label* elements.

Exercise 1: Using Styles to Create High-Contrast Elements

1. Create a new WPF application in Visual Studio.
2. In XAML view, just above the <*Grid*> declaration, create a *Window.Resources* section, as shown here:

```
<Window.Resources>

</Window.Resources>
```

3. In the *Window.Resources* section, create a high-contrast *Style* for *TextBox* controls that sets the background color to *Black* and the foreground to *White*. The *TextBox* controls also should be slightly larger by default. An example is shown here:

```
<Style TargetType="TextBox">
   <Setter Property="Background" Value="Black" />
   <Setter Property="Foreground" Value="White" />
   <Setter Property="BorderBrush" Value="White" />
   <Setter Property="Width" Value="135" />
   <Setter Property="Height" Value="30" />
</Style>
```

4. Create similar styles for *Button* and *Label*, as shown here:

```
<Style TargetType="Label">
   <Setter Property="Background" Value="Black" />
   <Setter Property="Foreground" Value="White" />
   <Setter Property="Width" Value="135" />
   <Setter Property="Height" Value="33" />
</Style>
<Style TargetType="Button">
   <Setter Property="Background" Value="Black" />
   <Setter Property="Foreground" Value="White" />
   <Setter Property="Width" Value="135" />
   <Setter Property="Height" Value="30" />
</Style>
```

5. Type the following in XAML view. Note that you should not add controls from the toolbox because that automatically sets some properties in the designer at a higher property precedence than styles:

```
<Label Margin="26,62,126,0" VerticalAlignment="Top">
   High-Contrast Label</Label>
<TextBox Margin="26,117,126,115">High-Contrast TextBox
   </TextBox>
<Button Margin="26,0,126,62" VerticalAlignment="Bottom">
   High-Contrast Button</Button>
```

6. Press F5 to build and run your application. Note that while the behavior of these controls is unaltered, their appearance has changed.

Exercise 2: Using Triggers to Enhance Visibility

1. In XAML view for the solution you completed in Exercise 1, add a *Style.Triggers* section to the *TextBox Style*, as shown here:

```
<Style.Triggers>

</Style.Triggers>
```

2. In the *Style.Triggers* section, add *Triggers* that detect when the mouse is over the control and enlarge the *FontSize* of the control, as shown here:

```
<Trigger Property="IsMouseOver" Value="True">
   <Setter Property="FontSize" Value="20" />
</Trigger>
```

3. Add similar *Style.Triggers* collections to your other two styles.
4. Press F5 to build and run your application. The *FontSize* of a control now increases when you move the mouse over it.

Lesson Summary

- *Styles* allow you to define consistent visual styles for your application. *Styles* use a collection of *Setters* to apply style changes. The most commonly used *Setter* type is the property setter, which allows you to set a property. Event setters allow you to hook up event handlers as part of an applied style.
- *Styles* can be set inline, but more frequently, they are defined in a *Resources* collection and are set by referring to the resource. You can apply a style to all instances of a control by setting the *TargetType* property to the appropriate type.
- *Styles* are most commonly applied declaratively, but they can be applied in code by creating a new style dynamically or obtaining a reference to a preexisting *Style* resource.
- You can create styles that inherit from other styles by using the *BasedOn* property.
- Property triggers monitor the value of a dependency property and can apply *Setters* from their *Setters* collection when the monitored property equals a predetermined value. Multi-triggers monitor multiple properties and apply their *Setters* when all monitored properties match corresponding specified values. Data triggers and multi-data-triggers are analogous but monitor bound values instead of dependency properties.
- Event triggers perform a set of *Actions* when a particular event is raised. They are used most commonly to control *Animations*.
- Property values follow a strict order of precedence depending on how they are set.

Lesson Review

You can use the following questions to test your knowledge of the information in Lesson 1, "Styles." The questions are also available on the companion CD if you prefer to review them in electronic form.

NOTE Answers

Answers to these questions and explanations of why each answer choice is correct or incorrect are located in the "Answers" section at the end of the book.

1. Look at the following XAML snippet:

```
<Window.Resources>
   <Style x:Key="Style1">
      <Setter Property="Label.Background" Value="Blue" />
      <Setter Property="Button.Foreground" Value="Red" />
      <Setter Property="Button.Background" Value="LimeGreen" />
   </Style>
</Window.Resources>
<Grid>
   <Button Height="23" Margin="81,0,122,58" Name="Button1"
      VerticalAlignment="Bottom">Button</Button>
</Grid>
```

   Assuming that the developer hasn't set any properties any other way, what is the *Background* color of *Button1?*

   A. Blue

   B. Red

   C. LimeGreen

   D. System Default

2. Look at the following XAML snippet:

```
<Window.Resources>
   <Style x:Key="Style1">
      <Style.Triggers>
         <MultiTrigger>
            <MultiTrigger.Conditions>
               <Condition Property="TextBox.IsMouseOver"
                  Value="True" />
               <Condition Property="TextBox.IsFocused"
                  Value="True" />
            </MultiTrigger.Conditions>
            <Setter Property="TextBox.Background"
               Value="Red" />
         </MultiTrigger>
      </Style.Triggers>
   </Style>
</Window.Resources>
<Grid>
   <TextBox Style="{StaticResource Style1}" Height="21"
      Margin="75,0,83,108" Name="TextBox1"
      VerticalAlignment="Bottom" />
</Grid>
```

When will *TextBox1* appear with a red background?

A. When the mouse is over *TextBox1*

B. When *TextBox1* is focused

C. When *TextBox1* is focused and the mouse is over *TextBox1*

D. All of the above

E. Never

3. Look at the following XAML snippet:

```
<Window.Resources>
   <Style TargetType="Button">
      <Setter Property="Content" Value="Hello" />
      <Style.Triggers>
         <Trigger Property="IsMouseOver" Value="True">
            <Setter Property="Content" Value="World" />
         </Trigger>
         <Trigger Property="IsMouseOver" Value="False">
            <Setter Property="Content" Value="How are you?" />
         </Trigger>
      </Style.Triggers>
   </Style>
</Window.Resources>
<Grid>
   <Button Height="23" Margin="81,0,122,58" Name="Button1"
      VerticalAlignment="Bottom">Button</Button>
</Grid>
```

What does *Button1* display when the mouse is NOT over the *Button*?

A. *Hello*

B. *World*

C. *Button*

D. *How are you?*

Lesson 2: Animations

Animations are another new feature of WPF. Animations allow you to change the value of a property over the course of a set period of time. Using this technique, you can create a variety of visual effects, including causing controls to grow or move abut the user interface, to change color gradually, or to change other properties over time. In this lesson, you learn how to create animations that animate a variety of property types and use *Storyboard* objects to control the playback of those animations.

After this lesson, you will be able to:

- Create and use animations
- Control animations with the *Storyboard* class
- Control timelines and playback of animations
- Implement simultaneous animations
- Use *Actions* to control animation playback
- Implement animations that use key frames
- Create and start animations in code

Estimated lesson time: 30 minutes

Using Animations

The term *animation* brings to mind hand-drawn anthropomorphic animals performing amusing antics in video media, but in WPF, animation has a far simpler meaning. Generally speaking, an animation in WPF refers to an automated property change over a set period of time. You can animate an element's size, location, color, or virtually any other property or properties associated with an element. You can use the *Animation* classes to implement these changes.

The *Animation* classes are a large group of classes designed to implement these automated property changes. There are 42 *Animation* classes in the *System.Windows.Media.Animation* namespace, and each one has a specific data type that they are designed to animate. *Animation* classes fall into three basic groups: Linear animations, key frame–based animations, and path-based animations.

Linear animations, which automate a property change in a linear way, are named in the format *<TypeName>Animation*, where *<TypeName>* is the name of the type being animated. *DoubleAnimation* is an example of a linear animation class, and that is the animation class you are likely to use the most.

Key frame–based animations perform their animation on the basis of several waypoints, called key frames. The flow of a key-frame animation starts at the beginning, and then progresses to each of the key frames before ending. The progression is usually linear. Key-frame animations are named in the format *<TypeName>AnimationUsingKeyFrames*, where *<TypeName>* is the name of the *Type* being animated. An example is *StringAnimationUsingKeyFrames*.

Path-based animations use a *Path* object to guide the animation. They are used most often to animate properties that relate to the movement of visual objects along a complex course. Path-based animations are named in the format *<TypeName>AnimationUsingPath*, where *<TypeName>* is the name of the type being animated. There are currently only three path-based *Animation* classes—*PointAnimationUsingPath*, *DoubleAnimationUsingPath*, and *MatrixAnimationUsingPath*.

Important Properties of Animations

Although there are many different *Animation* classes, they all work in the same fundamental way—they change the value of a designated property over a period of time. As such, they share common properties. Many of these properties also are shared with the *Storyboard* class, which is used to organize *Animation* objects, as you will see later in this lesson. Important common properties of the *Animation* and *Storyboard* classes are shown in Table 7-4.

Table 7-4 Important Properties of the *Animation* and *Storyboard* Classes

Property	Description
AccelerationRatio	Gets or sets a value specifying the percentage of the *Duration* property of the *Animation* that is spent accelerating the passage of time from zero to its maximum rate.
AutoReverse	Gets or sets a value that indicates whether the *Animation* plays in reverse after it completes a forward iteration.
BeginTime	Gets or sets the time at which the *Animation* should begin, relative to the time that the *Animation* is executed. For example, an *Animation* with a *BeginTime* set to 0:0:5 exhibits a 5-second delay before beginning.
DecelerationRatio	Gets or sets a value specifying the percentage of the duration of the *Animation* spent decelerating the passage of time from its maximum rate to zero.

Table 7-4 Important Properties of the *Animation* and *Storyboard* Classes

Property	Description
Duration	Gets or sets the length of time for which the *Animation* plays.
FillBehavior	Gets or sets a value that indicates how the *Animation* behaves after it has completed.
RepeatBehavior	Gets or sets a value that indicates how the *Animation* repeats.
SpeedRatio	Gets or sets the rate at which the *Animation* progresses relative to its parent.

In addition, the linear animation classes typically implement a few more important properties, which are described in Table 7-5.

Table 7-5 Important Properties of Linear Animation Classes

Property	Description
From	Gets or sets the starting value of the *Animation*. If omitted, the *Animation* uses the current property value.
To	Gets or sets the ending value of the *Animation*.
By	Gets or sets the amount by which to increase the value of the target property over the course of the *Animation*. If both the *To* and *By* properties are set, the value of the *By* property is ignored.

The following example demonstrates a very simple animation. This animation changes the value of a property that has a *Double* data type representation from 1 to 200 over the course of 10 seconds:

```
<DoubleAnimation Duration="0:0:10" From="1" To="200" />
```

In this example, the *Duration* property specifies a duration of 10 seconds for the animation, and the *From* and *To* properties indicate a starting value of 1 and an ending value of 200.

You might notice that something seems to be missing from this example. What property is this animation animating? The answer is that it is not animating any property—the *Animation* object carries no intrinsic information about the property that is being animated, but instead it is applied to a property by means of a *Storyboard*.

Storyboard Objects

The *Storyboard* is the object that controls and organizes animations in your user interface. The *Storyboard* class contains a *Children* collection, which organizes a collection of *Timeline* objects, which include *Animation* objects. When created declaratively in XAML, all *Animation* objects must be enclosed within a *Storyboard* object, as shown here:

```
<Storyboard>
   <DoubleAnimation Duration="0:0:10" From="1" To="200" />
</Storyboard>
```

Using a *Storyboard* to Control Animations

In XAML, *Storyboard* objects organize your *Animation* objects. The most important feature of the *Storyboard* object is that it contains properties that allow you to specify the target element and target property of the child *Animation* objects, as shown in bold in this example:

```
<Storyboard TargetName="Button1" TargetProperty="Height">
   <DoubleAnimation Duration="0:0:10" From="1" To="200" />
</Storyboard>
```

This example is now usable. It defines a timeline where over the course of 10 seconds, the *Height* property of *Button1* goes from a value of 1 to a value of 200.

The *TargetName* and *TargetProperty* properties are attached properties, so instead of defining them in the *Storyboard* itself, you can define them in the child *Animation* objects, as shown in bold here:

```
<Storyboard>
   <DoubleAnimation Duration="0:0:10" From="1" To="200"
      Storyboard.TargetName="Button1"
      Storyboard.TargetProperty="Height" />
</Storyboard>
```

Because a *Storyboard* can hold more than one *Animation* at a time, this configuration allows you to set separate target elements and properties for each animation. Thus, it is more common to use the attached properties.

Simultaneous Animations

The *Storyboard* can contain multiple child *Animation* objects. When the *Storyboard* is activated, all child animations are started at the same time and run simultaneously.

The following example demonstrates two simultaneous *Animations* that cause both the *Height* and *Width* of a *Button* element to grow over 10 seconds:

```
<Storyboard>
   <DoubleAnimation Duration="0:0:10" From="1" To="200"
      Storyboard.TargetName="Button1"
      Storyboard.TargetProperty="Height" />
   <DoubleAnimation Duration="0:0:10" From="1" To="100"
      Storyboard.TargetName="Button1"
      Storyboard.TargetProperty="Widtht" />
</Storyboard>
```

Using *Animations* with *Triggers*

You now have learned most of the story about using *Animation* objects. The *Animation* object defines a property change over time, and the *Storyboard* object contains *Animation* objects and determines what element and property the *Animation* objects affect. But there is still one piece that is missing: How do you start and stop an *Animation?*

All declaratively created *Animation* objects must be housed within a *Trigger* object. This can be either as a part of a *Style,* or in the *Triggers* collection of an *Element,* which accepts only *EventTrigger* objects.

Trigger objects define collections of *Action* objects, which control when an *Animation* is started and stopped. The following example demonstrates an *EventTrigger* object with an inline *Animation:*

```
<EventTrigger RoutedEvent="Button.Click">
   <EventTrigger.Actions>
      <BeginStoryboard>
         <Storyboard>
            <DoubleAnimation Duration="0:0:5"
               Storyboard.TargetProperty="Height" To="200" />
         </Storyboard>
      </BeginStoryboard>
   </EventTrigger.Actions>
</EventTrigger>
```

As you can see in the preceding example, the *Storyboard* object is enclosed in a *BeginStoryboard* tag, which itself is enclosed in the *EventTrigger.Actions* tag. *BeginStoryboard* is an *Action*–it indicates that the contained *Storyboard* should be started. The *EventTrigger* class defines a collection of *Actions* that should be initiated when the *Trigger* is activated, and in this example, *BeginStoryboard* is the action that is initiated. Thus, when the *Button* indicated in this trigger is clicked, the described *Animation* runs.

Using *Actions* to Control Playback

There are several *Action* classes that can be used to manage animation playback. These classes are summarized in Table 7-6.

Table 7-6 Animation-Related *Action* Classes

Action	Description
BeginStoryboard	Begins the child *Storyboard* object.
PauseStoryboard	Pauses the playback of an indicated *Storyboard* at the current playback position.
ResumeStoryboard	Resumes playback of an indicated *Storyboard*.
SeekStoryboard	Fast-forwards to a specified position in a target *Storyboard*.
SetStoryboardSpeedRatio	Sets the *SpeedRatio* of the specified *Storyboard*.
SkipStoryboardToFill	Moves the specified *Storyboard* to the end of its timeline.
StopStoryboard	Stops playback of the specified *Storyboard* and returns the animation to the starting position.

PauseStoryboard, ResumeStoryboard, SkipStoryboardToFill, and *StopStoryboard* are all fairly self-explanatory. They cause the indicated *Storyboard* to pause, resume, stop, or skip to the end, as indicated by the *Action* name. The one property that all these *Action* classes have in common is the *BeginStoryboardName* property. This property indicates the name of the *BeginStoryboard* object that the action is to affect. The following example demonstrates a *StopStoryboard* action that stops the *BeginStoryBoard* object named *stb1:*

```
<Style.Triggers>
   <EventTrigger RoutedEvent="Button.MouseEnter">
      <EventTrigger.Actions>
         <BeginStoryboard Name="stb1">
            <Storyboard>
               <DoubleAnimation Duration="0:0:5"
                  Storyboard.TargetProperty="Height" To="200" />
            </Storyboard>
         </BeginStoryboard>
      </EventTrigger.Actions>
   </EventTrigger>
   <EventTrigger RoutedEvent="Button.MouseLeave">
```

```
      <EventTrigger.Actions>
         <StopStoryboard BeginStoryboardName="stb1" />
      </EventTrigger.Actions>
   </EventTrigger>
</Style.Triggers>
```

All *Actions* that affect a particular *Storyboard* object must be defined in the same *Triggers* collection. The previous example shows both of these triggers being defined in the *Button.Triggers* collection. If you were to define these triggers in separate *Triggers* collections, storyboard actions would not function.

The *SetStoryboardSpeedRatio* action sets the speed ratio for the entire *Storyboard* and all *Animation* objects in that *Storyboard*. In addition to *BeginStoryboardName*, you must set the *SpeedRatio* property of this *Action* as well. The following example demonstrates a *SetStoryboardSpeedRatio* action that speeds the referenced *Storyboard* by a factor of 2:

```
<Style.Triggers>
   <EventTrigger RoutedEvent="Button.MouseEnter">
      <EventTrigger.Actions>
         <BeginStoryboard Name="stb1">
            <Storyboard>
               <DoubleAnimation Duration="0:0:5"
                  Storyboard.TargetProperty="Height" To="200" />
            </Storyboard>
         </BeginStoryboard>
      </EventTrigger.Actions>
   </EventTrigger>
   <EventTrigger RoutedEvent="Button.MouseLeave">
      <EventTrigger.Actions>
         <SetStoryboardSpeedRatio BeginStoryboardName="stb1" SpeedRatio="2" />
      </EventTrigger.Actions>
   </EventTrigger>
</Style.Triggers>
```

The *SeekStoryboard* action requires two additional properties to be set. The *Origin* property can be either a value of *BeginTime* or of *Duration* and specifies how the *Offset* property is applied. An *Origin* value of *BeginTime* specifies that the *Offset* is relative to the beginning of the *Storyboard*. An *Origin* value of *Duration* specifies that the *Offset* is relative to the *Duration* property of the *Storyboard*. The *Offset* property determines the amount of the offset to jump to in the animation. The following example shows a *SeekStoryboard* action that skips the referenced timeline to 5 seconds ahead from its current point in the timeline.

```
<Style.Triggers>
   <EventTrigger RoutedEvent="Button.MouseEnter">
      <EventTrigger.Actions>
```

```
            <BeginStoryboard Name="stb1">
               <Storyboard>
                  <DoubleAnimation Duration="0:0:10"
                     Storyboard.TargetProperty="Height" To="200" />
               </Storyboard>
            </BeginStoryboard>
         </EventTrigger.Actions>
      </EventTrigger>
      <EventTrigger RoutedEvent="Button.MouseLeave">
         <EventTrigger.Actions>
            <SeekStoryboard BeginStoryboardName="stb1" Origin="BeginTime"
               Offset="0:0:5" />
         </EventTrigger.Actions>
      </EventTrigger>
   </Style.Triggers>
```

Using Property Triggers with *Animations*

In the examples shown in this section, you have seen *Actions* being hosted primarily in *EventTrigger* objects. You can also host *Action* objects in other kinds of *Triggers. Trigger, MultiTrigger, DataTrigger, and MultiDataTrigger* objects host two *Action* collections: *EnterActions* and *ExitActions* collections.

The *EnterActions* collection hosts a set of *Actions* that are executed when the *Trigger* is activated. Conversely, the *ExitActions* collection hosts a set of *Actions* that are executed when the *Trigger* is deactivated. The following demonstrates a *Trigger* that begins a *Storyboard* when activated and stops that *Storyboard* when deactivated:

```
<Trigger Property="IsMouseOver" Value="True">
   <Trigger.EnterActions>
      <BeginStoryboard Name="stb1">
         <Storyboard>
            <DoubleAnimation Storyboard.TargetProperty="FontSize"
               To="20" Duration="0:0:.5" />
         </Storyboard>
      </BeginStoryboard>
   </Trigger.EnterActions>
   <Trigger.ExitActions>
      <StopStoryboard BeginStoryboardName="stb1" />
   </Trigger.ExitActions>
</Trigger>
```

Managing the Playback Timeline

Both the *Animation* class and the *Storyboard* class contain several properties that allow you to manage the playback timeline with a fine level of control. Each of these properties is discussed in this section. When a property is set on an *Animation,* the setting affects only that animation. Setting a property on a *Storyboard,* however, affects all *Animation* objects it contains.

AccelerationRatio and *DecelerationRatio*

The *AccelerationRatio* and *DecelerationRatio* properties allow you to designate a part of the timeline for acceleration and deceleration of the animation speed, rather than starting and playing at a constant speed. This is used sometimes to give an animation a more "natural" appearance. These properties are expressed in fractions of 1 and represent a percentage value of the total timeline. Thus, an *AccelerationRatio* with a value of .2 indicates that 20 percent of the timeline should be spent accelerating to the top speed. So the *AccelerationRatio* and *DecelerationRatio* properties should be equal to or less than 1 when added together. This example shows an *Animation* with an *AccelerationRatio* of .2:

```
<DoubleAnimation Duration="0:0:5" AccelerationRatio="0.2"
   Storyboard.TargetProperty="Height" To="200" />
```

AutoReverse

As the name implies, the *AutoReverse* property determines whether the animation automatically plays out in reverse after the end is reached. A value of *True* indicates that the *Animation* will play in reverse after the end is reached. *False* is the default value. The following example demonstrates this property:

```
<DoubleAnimation Duration="0:0:5" AutoReverse="True"
   Storyboard.TargetProperty="Height" To="200" />
```

FillBehavior

The *FillBehavior* property determines how the *Animation* behaves after it has completed. A value of *HoldEnd* indicates that the *Animation* holds the final value after it has completed, whereas a value of *Stop* indicates that the *Animation* stops and returns to the beginning of the timeline when completed. An example is shown here:

```
<DoubleAnimation Duration="0:0:5" FillBehavior="Stop"
   Storyboard.TargetProperty="Height" To="200" />
```

The default value for *FillBehavior* is *HoldEnd*.

RepeatBehavior

The *RepeatBehavior* property determines if and how an animation repeats. The *RepeatBehavior* property can be set in three ways. First, it can be set to *Forever,* which indicates that an *Animation* repeats for the duration of the application. Second, it can be set to a number followed by the letter *x* (for example, 2*x*), which indicates the number of times to repeat the animation. Third, it can be set to a *Duration,* which indicates the amount of time that an *Animation* plays, irrespective of the number of iterations. The following three examples demonstrate these settings. The first demonstrates an *Animation* that

repeats forever, the second an *Animation* that repeats three times, and the third an *Animation* that repeats for 1 minute:

```
<DoubleAnimation Duration="0:0:5" RepeatBehavior="Forever"
   Storyboard.TargetProperty="Height" To="200" />
<DoubleAnimation Duration="0:0:5" RepeatBehavior="3x"
   Storyboard.TargetProperty="Height" To="200" />
<DoubleAnimation Duration="0:0:5" RepeatBehavior="0:1:0"
   Storyboard.TargetProperty="Height" To="200" />
```

SpeedRatio

The *SpeedRatio* property allows you to speed up or slow down the base timeline. The *SpeedRatio* value represents the coefficient for the speed of the *Animation*. Thus, an *Animation* with a *SpeedRatio* value of 0.5 takes twice the standard time to complete, whereas a value of 2 causes the *Animation* to complete twice as fast. An example is shown here:

```
<DoubleAnimation Duration="0:0:5" SpeedRatio="0.5"
   Storyboard.TargetProperty="Height" To="200" />
```

Animating Non-Double Types

Most of the examples that you have seen in this lesson have dealt with the *DoubleAnimation* class, but in fact a class exists for every animatable data type. For example, the *ColorAnimation* class allows you to animate a color change, as shown here:

```
<Button Height="23" Width="100" Name="Button1">
   <Button.Background>
      <SolidColorBrush x:Name="myBrush" />
   </Button.Background>
   <Button.Triggers>
      <EventTrigger RoutedEvent="Button.Click">
         <BeginStoryboard>
            <Storyboard>
               <ColorAnimation Storyboard.TargetName="myBrush"
                  Storyboard.TargetProperty="Color" From="Red" To="LimeGreen"
                  Duration="0:0:5" />
            </Storyboard>
         </BeginStoryboard>
      </EventTrigger>
   </Button.Triggers>
</Button>
```

In this example, when the button is clicked, the background color of the button gradually changes from red to lime green over the course of 5 seconds.

NOTE In the standard Windows theme, this animation may conflict with other animations in the button's default template, so you might need to mouse out of the button and defocus it to see the full effect.

Animation with Key Frames

Up until now, all the animations you have seen have used linear interpolation—that is, the animated property changes take place over a linear timeline at a linear rate. You also can create nonlinear animations by using key frames.

Key frames are waypoints in an animation. Instead of allowing the *Animation* to progress linearly from beginning to end, key frames divide the animation up into short segments. The animation progresses from the beginning to the first key frame, then the next, and through the *KeyFrames* collection until the end of the animation is reached. Each key frame defines its own *Value* and *KeyTime* properties, which indicate the value that the *Animation* will represent when it reaches the key frame and the time in the *Animation* at which that frame will be reached.

Every data type that supports a linear *Animation* type also supports a key-frame *Animation* type, and some types that do not have linear animation types have key-frame *Animation* types. The key-frame *Animation* types are named *<TargetType>AnimationUsingKeyFrames*, where *<TargetType>* represents the name of the *Type* animated by the *Animation*. Key-frame *Animation* types do not support the *From*, *To*, and *By* properties; rather, the course of the *Animation* is defined by the collection of key frames.

There are three different kinds of key frames. The first is linear key frames, which are named *Linear<TargetType>KeyFrame*. These key frames provide points in an *Animation* that are interpolated between in a linear fashion. The following example demonstrates the use of linear key frames:

```
<DoubleAnimationUsingKeyFrames Storyboard.TargetProperty="Height">
   <LinearDoubleKeyFrame Value="10" KeyTime="0:0:1" />
   <LinearDoubleKeyFrame Value="100" KeyTime="0:0:2" />
   <LinearDoubleKeyFrame Value="30" KeyTime="0:0:4"/>
</DoubleAnimationUsingKeyFrames>
```

In the preceding example, the *Height* property goes from its starting value to a value of 10 in the first second, then to a value of 100 in the next second, and finally returns to a value of 30 in the last 2 seconds. The progression between each segment is interpolated linearly. In this example, it is similar to having several successive linear *Animation* objects.

Discrete Key Frames

Some animatable data types do not support gradual transitions under any circumstances. For example, the *String* type can only accept discrete changes. You can use discrete key frame objects to make discrete changes in the value of an animated property. Discrete key frame classes are named *Discrete<TargetType>KeyFrame*, where *<TargetType>* is the *Type* being animated. Like linear key frames, discrete key frames use a *Value* and a *KeyTime* property to set the parameters of the key frame. The following example demonstrates an animation of a *String* using discrete key frames:

```
<StringAnimationUsingKeyFrames Storyboard.TargetProperty="Content">
   <DiscreteStringKeyFrame Value="Soup" KeyTime="0:0:0" />
   <DiscreteStringKeyFrame Value="Sous" KeyTime="0:0:1" />
   <DiscreteStringKeyFrame Value="Sots" KeyTime="0:0:2" />
   <DiscreteStringKeyFrame Value="Nots" KeyTime="0:0:3" />
   <DiscreteStringKeyFrame Value="Nuts" KeyTime="0:0:4" />
</StringAnimationUsingKeyFrames>
```

Spline Key Frames

Spline key frames allow you to define a Bézier curve that expresses the relationship between animation speed and animation time, thus allowing you to create animations that accelerate and decelerate in complex ways. While the mathematics of Bézier curves is beyond the scope of this lesson, a Bézier curve is simply a curve between two points whose shape is influenced by two control points. Using spline key frames, the start and end points of the curve are always (0,0) and (1,1) respectively, so you must define the two control points. The *KeySpline* property accepts two points to define the Bézier curve, as seen here:

```
<SplineDoubleKeyFrame Value="300" KeyTime="0:0:6" KeySpline="0.1,0.8 0.6,0.6" />
```

Spline key frames are difficult to create with the intended effect without complex design tools, and are most commonly used when specialized animation design tools are available.

Using Multiple Types of Key Frames in an Animation

You can use multiple types of key frames in a single animation—you can freely intermix *LinearKeyFrame*, *DiscreteKeyFrame*, and *SplineKeyFrame* objects in the *KeyFrames* collection. The only restriction is that all key frames you use must be appropriate to the *Type* that is being animated. *String* animations, for example, can use only *DiscreteStringKeyFrame* objects.

Quick Check

- What are the different types of key frame objects? When would you use each one?

Quick Check Answer

- There are *LinearKeyFrame*, *DiscreteKeyFrame*, and *SplineKeyFrame* objects. *LinearKeyFrame* objects indicate a linear transition from the preceding property value to the value represented in the key frame. *DiscreteKeyFrame* objects represent a sudden transition from the preceding property value to the value represented in the key frame. *SplineKeyFrame* objects represent a transition whose rate is defined by the sum of an associated Bézier curve. You would use each of these types when the kind of transition represented was the kind of transition that you wanted to incorporate into your user interface. In addition, some animation types can use only *DiscreteKeyFrames*.

Creating and Starting Animations in Code

All the *Animation* objects that you have seen so far in this lesson were created declaratively in XAML. However, you can create and execute *Animation* objects just as easily in code as well.

The process of creating an *Animation* should seem familiar to you; as with other .NET objects, you create a new instance of your *Animation* and set the relevant properties, as seen in this example:

```
' VB
Dim aAnimation As New System.Windows.Media.Animation.DoubleAnimation()
aAnimation.From = 20
aAnimation.To = 300
aAnimation.Duration = New Duration(New TimeSpan(0, 0, 5))
aAnimation.FillBehavior = Animation.FillBehavior.Stop

// C#
System.Windows.Media.Animation.DoubleAnimation aAnimation = new
   System.Windows.Media.Animation.DoubleAnimation();
aAnimation.From = 20;
aAnimation.To = 300;
aAnimation.Duration = new Duration(new TimeSpan(0, 0, 5));
aAnimation.FillBehavior = Animation.FillBehavior.Stop;
```

After the *Animation* has been created, however, the obvious question is: How do you start it? When creating *Animation* objects declaratively, you must use a *Storyboard* to

organize your *Animation* and an *Action* to start it. In code, however, you can use a simple method call. All WPF controls expose a method called *BeginAnimation,* which allows you to specify a dependency property on that control and an *Animation* object to act on that dependency property. The following code shows an example:

```
' VB
Button1.BeginAnimation(Button.HeightProperty, aAnimation)

// C#
button1.BeginAnimation(Button.HeightProperty, aAnimation);
```

Lab: Improving Readability with Animations

In this lab, you improve upon your solution to the lab in Lesson 1 of this chapter. You remove the triggers that cause the *FontSize* to expand and instead use an *Animation* to make it look more natural. In addition, you create *Animation* objects to increase the size of the control when the mouse is over it.

Exercise: Animating High-Contrast Styles

1. Open the completed solution from the lab from Lesson 1 of this chapter.
2. In each of the *Styles,* remove the *FontSize Setter* that is defined in the *Trigger* and replace it with a *Trigger.EnterActions* and *Trigger.ExitActions* section, as shown here:

```
<Trigger.EnterActions>

</Trigger.EnterActions>
<Trigger.ExitActions>

</Trigger.ExitActions>
```

3. In each *Trigger.EnterActions* section, add a *BeginStoryboard* action, as shown here:

```
<BeginStoryboard Name="Storyboard1">

</BeginStoryboard>
```

4. Add the following *Storyboard* and *Animation* objects to the *BeginStoryboard* object in the style for the *TextBox.* Note that the values for the *ThicknessAnimation* object are crafted specifically for the completed version of the Lesson 1 lab on the CD. If you created your own solution, you need to recalculate these values:

```
<Storyboard Duration="0:0:1">
   <DoubleAnimation Storyboard.TargetProperty="FontSize"
      To="20" />
   <ThicknessAnimation Storyboard.TargetProperty="Margin"
      To="26,118,45,104" />
```

```
   <DoubleAnimation Storyboard.TargetProperty="Width" To="210"/>
   <DoubleAnimation Storyboard.TargetProperty="Height" To="40"/>
</Storyboard>
```

5. Add a similar *Storyboard* to the style for the *Label,* as shown here:

```
<Storyboard Duration="0:0:1">
   <DoubleAnimation Storyboard.TargetProperty="FontSize" To="20" />
   <ThicknessAnimation Storyboard.TargetProperty="Margin"
      To="26,62,46,-10" />
   <DoubleAnimation Storyboard.TargetProperty="Width" To="210"/>
   <DoubleAnimation Storyboard.TargetProperty="Height" To="40"/>
</Storyboard>
```

6. Add a similar *Storyboard* to the style for the *Button,* as shown here:

```
<Storyboard Duration="0:0:1">
   <DoubleAnimation Storyboard.TargetProperty="FontSize" To="20" />
   <ThicknessAnimation Storyboard.TargetProperty="Margin"
      To="26,0,46,52" />
   <DoubleAnimation Storyboard.TargetProperty="Width" To="210"/>
   <DoubleAnimation Storyboard.TargetProperty="Height" To="40"/>
</Storyboard>
```

7. Add the following line to the *Trigger.ExitActions* section of each *Style:*

```
<StopStoryboard BeginStoryboardName="Storyboard1" />
```

8. Press F5 to build and run your application. Now the *FontSize* expansion is animated and the control expands as well.

Lesson Summary

- Animation objects drive automated property changes over time. There are three different types of *Animation* objects—linear animations, key frame–based animations, and path-based animations. Every animatable type has at least one *Animation* type associated with it, and some types have more than one type of *Animation* that can be applied.
- Storyboard objects organize one or more *Animation* objects. Storyboard objects determine what objects and properties their contained *Animation* objects are applied to.
- Both *Animation* and *Storyboard* objects contain a variety of properties that control *Animation* playback behavior.
- Storyboard objects that are created declaratively are activated by a *BeginStoryboard* action in the *Actions* collection of a *Trigger. Triggers* also can define actions that pause, stop, and resume *Storyboard* objects, as well as performing other *Storyboard*-related functions.

- Key frame animations define a series of waypoints through which the *Animation* passes. There are three kinds of key frames: linear key frames, discrete key frames, and spline key frames. Some animatable types, such as *String*, support only discrete key frames.
- You can create and apply *Animation* objects in code. When doing this, you do not need to define a *Storyboard* object; rather, you call the *BeginAnimation* method on the element with which you want to associate the *Animation*.

Lesson Review

You can use the following questions to test your knowledge of the information in Lesson 2, "Animations." The questions are also available on the companion CD if you prefer to review them in electronic form.

NOTE Answers

Answers to these questions and explanations of why each answer choice is correct or incorrect are located in the "Answers" section at the end of the book.

---

1. How many times does the *Animation* shown here repeat (not counting the first iteration)?

```
<DoubleAnimation Duration="0:0:15" RepeatBehavior="0:1:0"
   Storyboard.TargetProperty="Height" To="200" />
```

   A. 0

   B. 1

   C. 2

   D. 3

2. Look at this *Animation:*

```
<DoubleAnimation Duration="0:0:5" From="30" By="80" To="200"
Storyboard.TargetProperty="Height" />
```

   Assuming that the element whose *Height* property it animates begins with a *Height* of 50, what is the value of the element after the animation has completed?

   A. 50

   B. 110

   C. 130

   D. 200

Chapter Review

To practice and reinforce the skills you learned in this chapter further, you can do any or all of the following:

- Review the chapter summary.
- Review the list of key terms introduced in this chapter.
- Complete the case scenarios. These scenarios set up real-world situations involving the topics of this chapter and ask you to create a solution.
- Complete the suggested practices.
- Take a practice test.

Chapter Summary

- *Styles* allow you to define consistent visual styles for your application by using a collection of *Setters*. They usually are defined as a *Resource* and referenced in XAML, though they can be set inline or dynamically. *Styles* can be inherited from other styles and applied to all instances of a particular type.
- Triggers respond to changes in the application environment. Property triggers and multi-triggers listen for changes in property values, and data triggers and multi-data-triggers listen for changes in bound values. When one of these triggers is activated, its *Setters* collection is applied. *EventTriggers* listen for a routed event and execute *Actions* in response to that event.
- Property values follow a strict order of precedence depending on how they are set.
- *Animation* objects drive automated property changes over time. There are three different types of *Animation* objects—linear animations, key frame–based animations, and path-based animations. Every animatable type has one or more *Animation* classes that can be used with it. *Animations* are organized by *Storyboard* objects, which are themselves controlled by *Action* objects that are activated in the *Action* collections of *Trigger* objects.
- *Animations* that use key frames provide waypoints that the *Animation* visits as it progresses. Key frames can be linear, spline-based, or discrete.
- You can create and apply *Animation* objects in code. When doing this, you do not need to define a *Storyboard* object, but rather you call the *BeginAnimation* method on the element with which you want to associate the *Animation*.

Key Terms

- Action
- Animation
- Key Frame
- Setter
- Storyboard
- Style
- Trigger

Case Scenarios

In the following case scenarios, you apply what you've learned about how to use controls to design user interfaces. You can find answers to these questions in the "Answers" section at the end of this book.

Case Scenario 1: Cup Fever

You've had a little free time around the office, and you decided to write a simple but snazzy application to organize and display results from World Cup soccer matches. The technical details are all complete: You've located a Web service that feeds up-to-date scores, and you've created a database that automatically applies updates from this service for match results and keeps track of upcoming matches. The database is exposed through a custom data object built on *ObservableCollection*<> lists. All that remains are the finishing touches. Specifically, when users choose an upcoming match from a drop-down box at the top of the window, you want the window's color scheme to match the colors of the teams in the selected matchup.

Technical Requirements

- The user interface is divided into two sections, each of which is built on a Grid container. Each section represents a team in the current or upcoming match. The user interface for each section must apply the appropriate team colors automatically when a new match is chosen.

Question

Answer the following question for all your office mates, who are eagerly awaiting the application's completion.

- How can you implement these color changes to the user interface?

Case Scenario 2: A Far-Out User Interface

Our friends with the questionable taste are back. They were so impressed with the work you did for them back in Chapter 4 that they've asked you to design a user interface that further pushes the envelope of good design sensibilities. Rather than having a static tie-dyed appearance, now they want the background to be a constantly changing multicolored experience. The idea of using a *RadialGradientBrush* to paint the background of the window is still acceptable, but they want the center of the gradient to change over time and they want the colors of the background to change.

Question

Answer the following question for your manager:

- How can we implement this appearance?

Suggested Practices

- Create an *Animation* that moves elements across the user interface. Alternatively, use linear animations and key frame animations to explore a variety of different animation styles. Animate other properties of UI elements as well, such as the color, size, and content.
- Use *Animations* to create a slideshow application that reads all the image files in a given directory and displays each image for 10 seconds before automatically switching to the next one. Note that you have to create and apply the *Animation* in code.
- Modify the solution from Lesson 2 of Chapter 6, "Converting and Validating Data," to create styles for the application that includes *DataTriggers* that automatically apply styles based on the *CompanyName* of the selected record.
- Modify the solution from the second lab in this chapter to reverse the *Animation* instead of stopping it when the mouse exits the control.

Take a Practice Test

The practice tests on this book's companion CD offer many options. For example, you can test yourself on just the content covered in this chapter, or you can test yourself on all the 70-502 certification exam content. You can set up the test so that it closely simulates the experience of taking a certification exam, or you can set it up in study mode so that you can look at the correct answers and explanations after you answer each question.

MORE INFO Practice tests

For details about all the practice test options available, see the section "How to Use the Practice Tests," in this book's Introduction.

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